01 SOLID FUELS

Sources, winning, properties

11/02447 Benefit of lignite as a filter aid for dewatering of digested sewage sludge demonstrated in pilot scale trials

Qi, Y. *et al. Chemical Engineering Journal*, 2011, 166, (2), 504–510.

Lignite, a low-rank coal, was investigated as a filter aid for the dewatering of digested sewage sludge at a pilot scale using a plate-and-frame filter press. When the lignite was used to condition the sludge at solids mass ratios of 0.5 to 1 and 1 to 1, the net sludge yield (Y_N) was found to increase from $1.2\,\mathrm{kg\,m^{-2}\,h^{-1}}$ without lignite conditioning to 5.2 and $7.8\,\mathrm{kg\,m^{-2}\,h^{-1}}$, respectively. Higher doses of the lignite did not result in further increases in the sludge yield due to the low mass fraction of the sludge solids in the cake. The filterability of lignite-conditioned sludge as affected by the flocculant dose was evaluated using specific resistance to filtration (SRF) as well as percentage sludge water removal and product solids content. Flocculation using ZETAG7501 at 19 kg/tonne reduced the SRF from 5.8×10^{13} at 11 kg/tonne to 9.3×10^{12}. Using the high molecular weight polymer ZETAG8125 at 13 kg/tonne achieved similar sludge water removal compared with using ZETAG7501 at 19 kg/tonne and even lower specific resistance. The improvement in sludge dewaterability by lignite conditioning confirmed the results from laboratory scale studies.

11/02448 Desulphurization of some low-rank Turkish lignites with crude laccase produced from *Trametes versicolor* ATCC 200801

Aytar, P. *et al. Fuel Processing Technology*, 2011, 92, (1), 71–76.

In this paper, data obtained during the oxidative desulfurization of some low-rank Turkish lignites with crude laccase enzyme produced from *Trametes versicolor* ATCC 200801 are presented. In order to optimize desulfurization conditions, effects of incubation time, pulp density, incubation temperature, medium pH, and also lignite source on the desulfurization have been examined. The values for incubation period, pulp density, temperature and pH in optimum incubation condition were found as 30 min, 5%, 35 °C, and pH 5.0, respectively. Under optimum conditions, treatment of coal samples with crude laccase has caused nearly 29% reduction in their total sulfur content. During the study, the rate of desulfurization of coal sample provided from Tuncbilek with crude laccase was found to be relatively higher than the other examined coal samples. Results of analytical assays have indicated that the treatment of coals with crude laccase has caused no change in their calorific values but reduced their sulfur emissions. 35%, 13%, and 25% reductions of pyritic sulfur, sulfate and organic sulfur in a period of 30 min were achieved, for a particle size of 200 μm under optimal conditions with enzymatic desulfurization. Also, statistical analyses such as Tukey multiple comparison tests and ANOVA were performed.

11/02449 High-resolution X-ray computed tomography observations of the thermal drying of lump-sized subbituminous coal

Mathews, J. P. *et al. Fuel Processing Technology*, 2011, 92, (1), 58–64.

Drying of low-rank coals affects coal cleaning, combustion, comminution, gasification, liquefaction, and in-seam fluid-flow (water, coalbed methane, and carbon dioxide for sequestration/enhanced coalbed methane). To evaluate the extent of drying-induced transitions, three lump-sized (approximately 6 × 2 × 2 cm) Powder River Basin subbituminous coal samples were thermally dried in an air-drying coal oven at 50 °C over 2 weeks. A high-resolution industrial X-ray computed tomography scanner was utilized to generate (non-destructively) three-dimensional regional volumetric renderings, as-received and over three stages of drying. The lumps had cleats, both open and mineral filled, with a degree of fracture diversity along the longitudinal plane. Comparison of the virtual slice surfaces, at identifiable locations, allowed the induced cracking and shrinkage accompanying the transitions during 19% moisture loss to almost dry to be observed. Under these drying conditions, the heat transfer, and thus extent of drying, proceeded radially inward. With increased drying time the fractures extend and become larger in aperture as the coal shrinks. The major fractures mostly followed the existing cleat system. With additional drying, these cleats widened and the aperture increase propagated deeper into the coal extended into the butt cleats. New fractures were located mostly perpendicular to the cleat fracture surface. The external volume of the coal lumps had limited shrinkage. The axial extent of the shrinkage length (lump edge to lump edge) was on the order of 4–6%, the bulk of the shrinkage being accommodated by the internal shrinkage between cleats.

11/02450 Influence of pulverized coal properties on heat release region in turbulent jet pulverized coal flames

Sung, Y. *et al. Experimental Thermal and Fluid Science*, 2011, 35, (4), 694–699.

The effects of pulverized coal properties, volatile matter, particle size and moisture content, on the heat release region in turbulent jet pulverized coal flames were investigated experimentally. To understand the accuracy of line of sight measurement in the two-dimensional (2-D) visualization, point measurements of chemiluminescence intensity by cassegrain optics were also conducted. The heat release region for the structure of pulverized coal flame was observed through visualization by CH* chemiluminescence image with an intensified high-speed camera, and by CH* chemiluminescence intensity for local point measurements. The streamwise length of the heat release region based on 2-D visualizations was about 11.4% longer than that of point measurements and increased proportionally to the volatile matter content. The temperature rise for 35–45 μm coal particles was faster than that for 75–90 μm particles, which resulted in a shift of reaction region toward upstream direction. The length of heat release region depends upon the particle size and the volatile matter. However, the coal moisture content less than 15% shows minor effect on the heat release region comparison to volatile matter and coal size within the experimental conditions.

11/02451 Mineralogy and geochemistry of Al-hydroxide/oxyhydroxide mineral-bearing coals of Late Paleozoic age from the Weibei coalfield, southeastern Ordos Basin, north China

Wang, X. *et al. Applied Geochemistry*, 2011, 26, (7), 1086–1096.

This paper describes the mineralogy and geochemistry of coals from the Weibei coalfield in the south-eastern Ordos Basin, north China. A number of Al-hydroxide/oxyhydroxide minerals were detected in the Late Carboniferous coals (Nos 5, 10 and 11 coals), especially in the No. 10 coal. Aluminium-hydroxide/oxyhydroxide minerals (nordstrandite, boehmite and diaspore) in the No. 10 coal are associated with kaolinite, suggesting that these minerals are derived from the breakdown of kaolinite. A model in which Al-hydroxide/oxyhydroxide minerals form from the incongruent dissolution of kaolinite is presented. Nordstrandite and boehmite mainly occur as massive lenses (<500 μm in length). Diaspore appears as massive aggregates and as single euhedral crystals (<50 μm in length) in a kaolinite matrix. The presence of high temperature quartz, and zircon indicates that there was input of felsic volcanic debris during accumulation of the Late Carboniferous coals. These volcanic materials have also had a significant influence on the enrichment of certain trace elements including Li, Be, Ga, Zr, Nb, Mo, Sn, W and U in the Late Carboniferous coals (Nos 5, 10, and 11 coals). SEM-EDX results show that Ga in the No. 10 coal (whole coal average 33.4 μg/g; $n = 2$) mainly occurs within Al-hydroxide/oxyhydroxide minerals (nordstrandite, boehmite, and diaspore), kaolinite and organic matter.

11/02452 Modeling changes of fractal pore structures in coal pyrolysis

Chen, Y. *et al. Fuel*, 2011, 90, (2), 499–504.

Coal pyrolysis processes are numerically investigated in mathematically produced coal pore models which simulate real coal pores in the parameters of the porosity and fractal dimension. The simulations include FG-DVC chemical reaction model, gas molecular diffusion in pores, energy conservation model and coal swelling model. Numerical results are verified by experimental results qualitatively, and they revealed that both the porosity and volatile contents of the parent coal can affect the fractal dimension of the final char pores after pyrolysis linearly. A formula to predict the fractal dimension of char pores from its parent coal properties is obtained by curve fitting in numerous results.

11/02453 Swelling of coal induced by cyclic sorption/desorption of gas: experimental observations indicating changes in coal structure due to sorption of CO_2 and CH_4

Majewska, Z. *et al. International Journal of Coal Geology*, 2010, 83, (4), 475–483.

Cyclic gas sorption/desorption experiments were made on two medium-rank coals from Lower and Upper Silesia basins, Poland, bituminous A and bituminous C. Measurements were made during two sets of experiments, in three successive cycles of sorption/desorption of gas on cylindrical coal specimens (diameter 22 mm, height 44 mm), cut with the long axis perpendicular to the bedding plane. Methane was used in the first group of tests, in the second, the coal specimen was in contact with CH_4 in the first and third cycles while during the middle one, the coal was subjected to sorption/desorption of CO_2. Experiments were conducted at 298 K, for a gas pressure of 4.0 MPa and changes in strain were monitored throughout. Sorption of CO_2 and CH_4 affected the two coals differently and there could be a connection between changes in the coal structure due to sorption of the gases and the character of the induced strain. The study of swelling induced in coal by sorption of CO_2/CH_4 was aimed at improving the understanding of coal behaviour, for practical reasons, as a part of an ECBM project.

Preparation

11/02454 A comparison of the results obtained from grinding in a stirred media mill lignite coal samples treated with microwave and untreated samples

Samanli, S. *Fuel*, 2011, 90, (2), 659–664.

Various studies have been carried out on the effect of microwave-treatment on grinding different types of coal. However, the effect of microwave treatment on grinding coal samples −3.35 mm in size which can be considered to be fine is still under investigation. The purpose of this paper is to make contributions to these studies conducted. In the study, lignite coal samples with pyritic sulfur and 25% structural moisture were crushed below −3.35 mm particle size using jaw and cone crushers and then classified into three different mono size groups by Russel sieve. For a complete removal of the structural moisture from the lignite coal, a microwave application with 600 W needs approximately 35% more energy consumption than that with 850 W. The untreated coal samples and the ones treated with microwave at 850 W were ground for 5, 15, 30, 60, 120 s in a stirred media mill. The breakage rates of microwave-treated coal increased and accordingly the ground products of microwave-treated coal yielded finer particles than −106 μm as compared to untreated coals. The untreated and microwave-treated feed coals of −3350 μm and −1180 μm particle sizes were ground for 2 min in the stirred media mill. It was found that the increases in the rate of weight percentages for −106 μm particle size fraction after 2 min of grinding of untreated and microwave-treated feed coals of −3350 μm and −1180 μm were found to be 15.81% and 2.69%, respectively. Moreover, Hardgrove index (HGI) test results of lignite coal showed that the HGI index value increased by approximately 23% after microwave treatment with 850 W.

11/02455 Alkaline hydrothermal de-ashing and desulfurization of low quality coal and its application to hydrogen-rich gas generation

Tri Mursito, A. *et al. Energy Conversion and Management*, 2011, 52, (1), 762–769.

This paper describes experimental research and a fundamental study of alkaline hydrothermal treatment of high-sulfur, high-ash coal from Banten, Java, Indonesia. Experiments were carried out on a laboratory-scale 0.5 L batch reactor. The alkaline hydrothermal treatment gave upgraded clean coal with low sulfur content (about 0.3 wt%) and low ash content (about 2.1 wt%). A zero carbon dioxide and pure hydrogen gas were produced at 330 °C by introducing an alkali (sodium hydroxide, NaOH) to the hydrothermal treatment of raw coal. X-ray diffraction (XRD) and X-ray fluorescence (XRF) techniques were used to test for the removal or reduction of major inorganic elements in the coal, and changes in carbon-functional groups and their properties were determined by Fourier transform infrared spectroscopy (FTIR) and carbon-13 of nuclear magnetic resonance (^{13}C NMR) tests on the product of the hydrothermal upgrading and demineralization process.

11/02456 Effects of addition of Mo on the sulfidation properties of Fe-based sorbents supported on fly ash during hot coal gas desulfurization

Wang, D. *et al. Chemical Engineering Journal*, 2011, 166, (1), 362–367.

This paper studies the influence of the addition of Mo on the sulfidation performance of Fe-based sorbent supported on fly ash for hot coal gas desulfurization. Sorbent samples were prepared using physical mixing method with different Mo oxide content. The sulfidation experiments were carried out in the temperature range of 400–600 °C. Gas compositions were analysed using a gas chromatogram. The structure and morphology of sorbent samples before and after sulfidation were examined by using SEM, XRD and compressive strength was also measured. The experimental results show that the fly ash supporter has some capability for sulfur removal from the hot coal gas. The addition of Mo may effectively improve the desulfurization efficiency and increase the compressive strength of iron-based sorbents.

11/02457 Effects of effective stress changes on permeability of latrobe valley brown coal

Jasinge, D. *et al. Fuel*, 2011, 90, (3), 1292–1300.

One of the key issues with geological sequestration of carbon dioxide in coal seams is change of permeability caused by carbon dioxide (CO_2) injection, and especially any resulting reduction in injectivity. Injection causes changes in pressure and effective stress, with further changes caused by coal matrix swelling associated with adsorption of CO_2. In this paper the authors aim to study how the change in effective stress and coal swelling may influence the gas permeability in brown coal using natural coal and reconstituted coal specimens. Tests were conducted at different confining pressures to represent conditions at different depths. Different gas injection pressures were also employed at each confining stress stage. The test results clearly depicted an exponential reduction of coal permeability to CO_2 gas when effective stress increases. Based on the experimental results, an empirical correlation to represent the effect of stress on permeability was developed. The results also showed that increase in pore pressure can induce further swelling of the coal specimens, and this can lead to further decrease in permeability which can have important impact on field injectivity. Test results for natural brown coal specimens were compared with results of tests on reconstituted coal specimens made from compaction of coal particles obtained from crushing of blocks of natural coal. Observed permeability behaviour of gas in reconstituted coal was similar to the natural coal specimen permeability trend, when effective stress increases.

11/02458 Evaluation of stress-controlled coal swelling processes

Liu, J. *et al. International Journal of Coal Geology*, 2010, 83, (4), 446–455.

Stress-controlled swelling tests are normally conducted in the laboratory to characterize the evolution of coal permeability under the influence of gas sorption. Typically reductions in permeability are observed from gas-sorption-induced swelling even where effective stresses remain constant. This behaviour remains enigmatic as the permeability of the porous coal is determined by the effective stress only. When these observations were interpreted, a matchstick or cubic coal model was assumed. Under this assumption, matrix swelling would not affect coal permeability because of the complete separation between matrix blocks caused by through-going fractures. This is why current coal permeability models have little success in explaining this inconsistency. It is generally believed that the reason for the failure is the inconsistency between the experimental conditions and the model assumptions. However, in this paper, it is considered that the reason may be the internal actions between coal fractures and matrixes have not been taken into consideration. In this study, a model capable of replicating this apparently anomalous behaviour is developed. The authors consider the interactions of the fractured coal mass where cleats do not create a full separation between adjacent matrix blocks but where solid rock bridges are present. The authors accommodate the role of swelling strains both over contact bridges that hold cleat faces apart but also over the non-contacting span between these bridges. The effects of swelling act competitively over these two components: increasing porosity and permeability due to swelling of the bridging contacts but reducing porosity and permeability due to the swelling of the intervening free-faces. Under these conditions, a new permeability model is formulated. The new model is the key cross link that couples the multiphysics of coal–gas interactions. The formulation and incorporation of this permeability model into the multiphysics simulation of coal–gas interactions are presented in this paper.

11/02459 Feasibility of using ultrasound-assisted process for sulfur and ash removal from coal

Ambedkar, B. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (3), 236–246.

The present work investigates utilization of ultrasound in reagent-based coal de-ashing and desulfurization. The coal under study was received from Girald mine, Rajasthan, India. Three different ultrasonic frequencies (25 kHz, dual (58/192 kHz) and 430 kHz) and three reagents (HCl, HNO_3 and H_2O_2) were used. The study employed a Taguchi fractional-factorial L_{27} DOE. Experimental data were used to derive an empirical model for the prediction of total sulfur removal. The model incorporates cavitational intensity, reagent concentration, sonication time, coal particle size and coal concentration as key parameters. Effects of above factors on reagent-based ultrasonic coal-desulfurization are presented here. An optimum set of process parameters are identified and validated. Larger-scale trial with high-ash and high-sulfur coals is strongly recommended.

11/02460 Petrographic, mineralogical and geochemical characterization of the Serrinha coal waste pile (Douro coalfield, Portugal) and the potential environmental impacts on soil, sediments and surface waters

Ribeiro, J. *et al. International Journal of Coal Geology*, 2010, 83, (4), 456–466.

Serrinha is the largest coal waste pile resulting from mining activities in the Douro coalfield, Portugal. The exploitation of anthracite in tens of small mines caused some environmental impacts, as is the case of the coal waste piles that exist in old mines and adjacent areas. The Serrinha waste pile is essentially made up of 2 million tonnes of shales and carbonaceous shales, deposited in a topographical depression over about 30 years. Despite the environmental restoration accomplished in the Serrinha waste pile, some environmental problems seem to persist. In this study a petrographic, mineralogical and geochemical characterization was done in order to recognize and understand these problems. The materials studied were coal waste, sediments and waters from the drainage system and decanting basins, soils from the surrounding areas, leachates from waste material and neoformed minerals formed at the bottom of the waste pile. The main lithologies (carbonaceous shale and lithic arenite) and coal from the Douro coalfield were also analysed. Petrographic analysis shows some evidence of weathering (on organic and inorganic matter) related to the time of exposure to the weathering agents and the easy access of air within the waste pile (due to both the poor compaction and the heterogeneity of the material). Mineralogically, the composition of coal waste material has contributions from both the coal and the associated lithologies. R-type cluster analysis of the waste pile material allows two distinct clusters to be identified. In the first cluster a sulfide fraction is represented by the association of As, Cd, Cu, Pb, Ni and Zn, while Fe clustered with Al, Co, and Ti indicates that some of the Fe and the other elements are likely associated with silicate minerals such as clays. The second cluster, represented by Cr, V, Zr, Rb, REE, Mn, Li and Ba, probably represent a silicate fraction, perhaps detrital accessory minerals. The waste pile material, leachates, soils, sediments, neoformed minerals and water analyses indicate the existence of potential environmental impacts due to the acid mine drainage and associated leaching of heavy metals and other elements.

Economics, business, marketing, policy

11/02461 DEA approach for unified efficiency measurement: assessment of Japanese fossil fuel power generation

Sueyoshi, T. and Goto, M. *Energy Economics*, 2011, 33, (2), 292–303.

This study discusses a new data envelopment analysis (DEA) approach to measure the unified (operational and environmental) efficiency of energy firms. It is widely known that they produce not only desirable (good) outputs (e.g. electricity) but also undesirable (bad) outputs (e.g. CO_2) as a result of their plant operations. The proposed approach incorporates an output separation (desirable and undesirable outputs) for the performance evaluation of energy firms. In addition to the output separation, this study separates inputs into energy and non-energy inputs. Consequently, the proposed approach incorporates not only the output separation but also the input separation within a computational framework of DEA non-radial measurement. This study compares the proposed approach with other previous DEA approaches used for the performance evaluation of energy firms. After the methodological comparison, this study applies the proposed approach for measuring the unified efficiency of Japanese fossil fuel power generation. This empirical study confirms that the implementation of 2005 Kyoto Protocol has not been effective on the unified efficiency of Japanese fossil fuel power generation during the observed period (2004–2008). Although the empirical result is inconsistent with the current Japanese environmental policy under Kyoto Protocol, it contains policy implications for guiding the future direction of Japanese environmental policy on the electric power industry.

11/02462 Effects of consumer subsidy on household fuel switching from coal to cleaner fuels: a case study for anthracites in Korea

Park, H. and Kwon, H. *Energy Policy*, 2011, 39, (3), 1687–1693.

The Korean coal industry is in a transition under low carbon policy through the steady reduction of coal production. Since consumer subsidy for the consumption of anthracites briquette in low-income households caused a distortion in domestic coal market, the so-called coupon program will be the first target in energy reform policy in order to induce fuel switching from anthracites to alternative clean energy. This paper tries to identify various factors that influence households' fuel switching decision. Disutility from briquette consumption is also considered as an important factor. Using the 2007 census data on briquette-consuming households, it is found that the coupon program provides an adverse effect to switching fuels to clean energy while the disutility of briquettes is positively associated with the probability of fuel switching. However, the empirical finding suggests that the policy alone attempting to remove coupon program may fail to switch fuels unless the cost of boiler changes is substantially reduced through the provision of accessible networks to alternative energy sources. It indicates that reform policy for consumer subsidy must be understood in line with more comprehensive regional energy plans to resolve energy poverty issue.

11/02463 Modeling technological learning and its application for clean coal technologies in Japan

Nakata, T. *et al. Applied Energy*, 2011, 88, (1), 330–336.

Estimating technological progress of emerging technologies such as renewables and clean coal technologies becomes important for designing low carbon energy systems in future and drawing effective energy policies. Learning curve is an analytical approach for describing the decline rate of cost and production caused by technological progress as well as learning. In the study, a bottom-up energy-economic model including an endogenous technological learning function has been designed. The model deals with technological learning in energy conversion technologies and its spillover effect. It is applied as a feasibility study of clean coal technologies such as IGCC (integrated coal gasification combined cycle) and IGFC (integrated coal gasification fuel cell system) in Japan. As the results of analysis, it is found that technological progress by learning has a positive impact on the penetration of clean coal technologies in the electricity market, and the learning model has a potential for assessing upcoming technologies in future.

11/02464 Techno-economic evaluation of coal-based polygeneration systems of synthetic fuel and power with CO_2 recovery

Lin, H. *et al. Energy Conversion and Management*, 2011, 52, (1), 274–283.

Being abundant in coal but short of oil and gas, China heavily depends on coal, which leads to the challenge to efficiently producing synthetic fuels based on coal with lower CO_2 emissions. In this paper, polygeneration systems with and without CO_2 recovery are analysed from the techno-economic viewpoint. The results show that energy penalty plays the important role in the cost penalty for CO_2 recovery. With system integration, the polygeneration technology can achieve the trade-off between primary installed capital cost and fuel saving, which can effectively reduce the cost penalty for CO_2 avoidance. Compared to the pulverized-coal power system and MEOH single-product system, the polygeneration system with CO_2 recovery can get the cost penalty as low as \$3.1/t-CO_2. Compared to the polygeneration system without CO_2 recovery, the cost penalty may be near zero. Considering the trend of learning-by-doing, products cost of the polygeneration system has double dropping potential as that of the traditional methanol production system and IGCC system.

11/02465 The role of coal in energy policy and sustainable development of Turkey: is it compatible to the EU energy policy?

Baris, K. *Energy Policy*, 2011, 39, (3), 1754–1763.

This paper aims to assess the current and future role of coal in energy strategy of Turkey, and evaluates the compatibility of policies to the EU energy policy and strategy. Coal is regarded as the most important indigenous energy source in Turkey together with hydropower to strengthen the supply security of the country. Turkish government set targets to fully utilize coal reserves of the country in next decades. However, the country is also in the process of becoming an EU member state, hence, it is expected that the energy policies have to comply with the EU. Moreover, Turkey ratified Kyoto Protocol in 2009, thus the country should limit CO_2 emission together with other greenhouse gases. The probable obstacles that Turkey may face due to the utilization of coal were determined as CO_2 emissions, lack of technology and application in carbon capture and storage and health and safety issues. It is concluded that coal is a very important domestic energy source for Turkey but new policies have to be developed and adopted immediately, and more realistic targets for the country should be set accordingly.

11/02466 Trend of technology innovation in China's coal-fired electricity industry under resource and environmental constraints

Yu, F. *et al. Energy Policy*, 2011, 39, (3), 1586–1599.

This research builds a technology-based bottom-up model to estimate the performance of China's coal-fired electricity industry on resource consumption and environmental emissions. From the integrated estimation of three scenarios characterizing different stages of technology innovation in 2007–2030, technology innovation is proven to be the determinant in decreasing resource use and environmental effects from electricity production, but analysis based on current policies reveals some doubt in achieving the coal consumption intensity control target. Constrained with national control targets, the best route of technology innovation is calculated by integrated benefit targeting optimization. Supercritical (SC) and ultra-supercritical (USC) pressure boilers, flue gas desulfurization (FGD) and closed-cycle wet cooling with a high circulation ratio will be the mainstream technologies before 2030 based on current policy. It is inevitable to close or reconstruct small power plants from the late 2010s, and integrated gasification combined cycle (IGCC) and pressurized fluidized bed combustion combined cycle (PFBC-CC) plants will show a competitive advantage in the late 2020s. However, air cooling and FGD systems will expand slower than the authorities' expectation, while higher water prices and SO_2 charges promote the expansion. Stricter restrictions are also found to be positive for technological progress.

Derived solid fuels

11/02467 Behavior of coal chlorine in cokemaking process

Nomura, S. *International Journal of Coal Geology*, 2010, 83, (4), 423–429.

The behavior of coal chlorine in metallurgical cokemaking process was investigated. Various coals were carbonized (heat-treated) in a nitrogen atmosphere and the ratio of the chlorine in the heat-treated sample to that in the coal was defined as the chlorine residue ratio. The release of chlorine from coal during carbonization is a slow process and the chlorine residue ratio decreased with increasing the heat-treatment temperature, increasing the soaking time, and decreasing the heating rate. It increased with increasing the Ca content in coal and with an addition of CaO. This is because chlorine in coal is released as HCl, which is trapped in coke again in the form of $CaCl_2$. The chlorine residue ratio of coke produced in an actual coke oven was higher than that of coke produced in a laboratory-scale tube furnace. This is because released gas from coal has more chances to contact with calcium in the actual coke oven than in the tube furnace. Moreover, the removal of chlorine from NaCl was promoted by the co-carbonization of NaCl with coal, which implies that H_2O derived from coal decomposition may help chlorine to be released.

11/02468 Coal char reactivity as a fuel selection criterion for coal-based hydrogen-rich gas production in the process of steam gasification

Smoliński, A. *Energy Conversion and Management*, 2011, 52, (1), 37–45.

The fuel's reactivity can be defined as a parameter determining its processability in thermochemical processes applied to convert them into energy and/or energy carriers. It depends on many factors, like chemical composition and physical properties of a fuel as well as process parameters. As such it may provide important information on the process results in terms of product output and quality. In the paper the results of reactivity tests performed for Polish hard coals in the process of steam gasification in a fixed bed reactor system as well as the analysis of potential relationships between the reactivity and selected physical and chemical parameters of coal and products quality and quantity using chemometric method (principal component analysis) are presented. The analysis revealed a negative correlation between $R_{\max}$ and the total volume of synthesis gas produced in the process. This regularity was confirmed in the tests of steam gasification of coal to hydrogen-rich gas with CO_2 capture under atmospheric pressure and at the temperature of 700 °C.

11/02469 Kinetic study for the reduction of residual char particles using oxygen and air

Molintas, H. *et al. Applied Energy*, 2011, 88, (1), 306–315.

This study characterizes the chemical kinetics for the reduction and elimination of char particles using air and pure oxygen as the oxidants. Commercial carbon black was used as char for the experimental studies reported here. Different oxidant injection flow rates have been examined at various injection temperatures between 400 and 700 °C under atmospheric pressure conditions to obtain the intrinsic kinetic parameters. The char conversion rates have been measured in a laminar flow hot stream using 0.2 and 0.3 g mass of initial char samples. The kinetic parameters are obtained by fitting the available experimental data into the derived one-film model. The proposed one-film model is compared and analysed for consistency and reliability for the calculated intrinsic kinetic parameters.

11/02470 Study on coal chars combustion under O_2/CO_2 atmosphere with fractal random pore model

Fei, H. *et al. Fuel*, 2011, 90, (2), 441–448.

When predicting the variation of pore structure during O_2/CO_2 combustion of coal chars using the random pore model (RPM), it is impossible to calculate exactly the structure parameter ψ from the pore characteristics. The values of structure parameter ψ, which were calculated based on its fractal feature at various carbon conversions, should be almost constant. However, this investigation exhibited a drastic increase of ψ at the end of combustion reaction. In this work, structure parameter ψ of the RPM was modified according to the experimental analysis and a new model, fractal random pore model (FRPM), was constructed. Compared with other models such as RPM, discrete random pore model (DRPM), the Struis model (model I) and the Liu model (model II), it was found that fractal random pore model was more accurate to describe coal chars combustion, especially at higher conversions. Using the FRPM, O_2/CO_2 isotherm combustion of coal chars were analysed at different temperatures.

02 LIQUID FUELS

Sources, properties, recovery

11/02471 Investigations on surrogate fuels for high-octane oxygenated gasolines

Machado, G. B. *et al. Fuel*, 2011, 90, (2), 640–646.

Gasoline is a complex mixture that possesses a quasi-continuous spectrum of hydrocarbon constituents. Surrogate fuels that decrease the chemical and/or physical complexity of gasoline are used to enhance the understanding of fundamental processes involved in internal combustion engines (ICEs). Computational tools are largely used in ICE development and in performance optimization; however, it is not possible to model full gasoline in kinetic studies because the interactions among the chemical constituents are not fully understood and the kinetics of all gasoline components are not known. Modelling full gasoline with computer simulations is also cost prohibitive. Thus, surrogate mixtures are studied to produce improved models that represent fuel combustion in practical devices such as homogeneous charge compression ignition (HCCI) and spark ignition (SI) engines. Simplified mixtures that represent gasoline performance in commercial engines can be used in investigations on the behaviour of fuel components, as well as in fuel development studies. In this study, experimental design was used to investigate surrogate fuels. To this end, SI engine dynamometer tests were conducted, and the performance of a high-octane, oxygenated gasoline was reproduced. This study revealed that mixtures of iso-octane, toluene, *n*-heptane and ethanol could be used as surrogate fuels for oxygenated gasolines. These mixtures can be used to investigate the effect of individual components on fuel properties and commercial engines performance.

11/02472 Modeling of asphaltene deposition in oil reservoirs during primary oil recovery

Solaimany-Nazar, A. R. and Zonnouri, A. *Journal of Petroleum Science and Engineering*, 2011, 75, (3–4), 251–259.

Asphaltene deposition in oil reservoirs during primary oil recovery and using the enhanced oil recovery methods are complicated and destructive problem with which most of the oil field in worlds has encountered. In this research, the examination of formation damage due to the asphaltene deposition, a four-phase black oil model (oil, water, gas, and asphaltene) is developed in combination with proper thermodynamic and deposition models in cylindrical coordinates around a well in a reservoir. Subsequently, this model has been used for examining the effect of well production rate and the initial reservoir permeability on the asphaltene deposition behaviour in a typical reservoir during primary production process. The results of model indicate that at a fixed permeability, with increase in the production rate, the amount of asphaltene deposits will increase. However, an increase in the reservoir permeability will decrease the deposition rate because of the existence of further channels for flow.

11/02473 Modeling of vapor-liquid equilibrium of gasoline-ethanol blended fuels for flash boiling simulations

Neroorkar, K. and Schmidt, D. *Fuel*, 2011, 90, (2), 665–673.

Flash boiling is a physical phenomenon which governs the non-equilibrium phase change of a high temperature fluid as it is depressurized below its vapour pressure. The modelling of this process is of importance to a number of industrial applications and requires the liquid–liquid equilibrium properties of the fluid under consideration. The highly non-ideal nature of gasoline-ethanol fuel blends makes liquid–liquid equilibrium calculations extremely difficult for such fluids. A simple model known as GEFlash (gasoline–ethanol flash), based on existing literature and fundamental chemical engineering thermodynamics is proposed to calculate the properties of gasoline–ethanol fuel blends that are required to perform flash boiling simulations. In addition, a second model based on the chemical engineering software Aspen Plus is also proposed and the predictions of the two models are validated against experimental data available in open literature. The results indicate that both models reproduce the trend in experimental data for liquid pressures and saturated liquid density for blends with different ethanol contents. The GEFlash model does not match the liquid mole fraction predictions of the Aspen Plus model for fuels with low ethanol content (E20 and E40). However, the liquid mole fractions for high ethanol content fuels (greater than E60) are accurate over the majority of the temperature range tested.

11/02474 Oxygenated transportation fuels. Evaluation of properties and emission performance in light-duty vehicles in Mexico

Schifter, I. *et al. Fuel*, 2011, 90, (2), 779–788.

Recently a biofuels promotion and development law was approved in Mexico that requires increasing volumes of renewable to blend into the transportation fuel pool, much of which is likely to be ethanol. Emissions data under the three different driving conditions of the US FTP-75 certification cycle were obtained for regulated, toxic and carbonyl compounds using recent model year vehicles representing 61% of the typical fleet available in Mexico. Ozone-forming potential and specific reactivity of tailpipe and evaporative emissions were also calculated. Comparison were performed using the traditional methyl-tertiary butyl ether employed in Mexico with an ethanol fuel at the same level of oxygen content, taking into account the current fuel specifications and the stream stocks available at the Mexican refineries. The results suggest that the contribution of cold start to regulated emissions range from 37% to 40% whiles those of toxic from 40% to 47% in both fuels. Results also indicate an increase in the rates of evaporative emissions of higher specific reactivity with the ethanol fuel. Estimation of the percent reduction of pollutants using the complex model of the US Environmental Protection Agency suggests that volatile organic compounds will exceeds the limits imposed by the model if vapour pressure of the ethanol gasoline is not properly adjusted.

11/02475 Predicting bottomhole pressure in vertical multiphase flowing wells using artificial neural networks

Jahanandish, I. *et al. Journal of Petroleum Science and Engineering*, 2011, 75, (3–4), 336–342.

Accurate prediction of pressure drop has been important in vertical multiphase flowing oil wells in order to design an effective production string and optimum production strategy selection. Various scientists and researchers have proposed correlations and mechanistic models for this purpose since 1950, most of which are widely used in the industry. But in spite of recent improvements in pressure prediction techniques, most of these models fail to provide the desired accuracy of pressure drop, and further improvement is still needed. This study presents an artificial neural network (ANN) model for prediction of the bottomhole flowing pressure and consequently the pressure drop in vertical multiphase flowing wells. The model was developed and tested using field data covering a wide range of variables. A total of 413 field data sets collected from Iran fields were used to develop the ANN model. These data sets were divided into training, validation and testing sets in the ratio of 4:1:1. The results showed that the research model significantly outperforms all existing methods and provides predictions with higher accuracy, approximately 3.5% absolute average percent error and 0.9222 correlation coefficient.

Transport, refining, quality, storage

11/02476 Bourgas–Alexandroupolis oil pipeline; will matching institutional and regulatory contexts lead to an effective bargaining and eventual consensus?

Menegaki, A. N. *Energy Policy*, 2011, 39, (3), 1277–1285.

This paper uses bargaining principles/prerequisites for an effective bargaining result to decide whether Greece and Bulgaria can form a successful energy coalition. Motivation for this is the proposed construction of the crude oil pipeline from the Bulgarian port Burgas to the Greek Aegean port of Alexandroupolis. The reason Turkey is the third country in the analysis despite its current non-membership in this venture, is that: (i) Turkey offers to host a competitive route of the pipeline, (ii) it is a transit, neighbouring country to Greece forming an important geopolitical triangle together with Greece and Bulgaria and (iii) co-operates separately with Bulgaria and Greece in other energy pipelines. Therefore, the three countries engage to interwining energy and geopolitical futures. Whether B–A oil pipeline will be implemented or not, will be due to a mix of bargaining procedures. The paper shows that the principles/prerequisites for an effective bargaining result, through their constituents (selected economy and energy figures and characteristics), are fulfilled by Greece and Bulgaria. A broader coalition with the inclusion of Turkey might also be permissible and promising based on this theory.

11/02477 COSMO-RS based predictions for the desulphurization of diesel oil using ionic liquids: effect of cation and anion combination

Anantharaj, R. and Banerjee, T. *Fuel Processing Technology*, 2011, 92, (1), 39–52.

Ionic liquids (ILs) provide an important alternative in removing aromatic sulfur compounds by liquid–liquid extraction (LLE). A total of 28 anions and six cations resulting in 168 possible combinations were screened via the conductor-like screening model for real solvents (COSMO-RS). Initially, benchmarking was performed to predict the infinite dilution activity coefficients of thiophene in ionic liquids. Comparison with literature values involving eight ILs with 20 points gave the average root mean square deviation (RMS) to be 11%. Thereafter artificial simulated diesel, aromatic sulfur compound and the cation and anion combination was used to predict the capacity (C) and selectivity (S) at infinite dilution. In general the selectivities were found to decrease in the following order: thiophene (4–24) > benzothiophene (2–12) > dibenzothiophene (1–7). The different hetero atom (N,S,O) and its location in the cation structure strongly influenced the selectivity and capacity at infinite dilution for all the three aromatic sulfur compounds. It was found that the cation without the aromatic ring combined with anions having sterical shielding effect such as [SCN], [CH_3SO_3], [CH_3COO], [Cl], and [Br] proved to be the most favourable IL for desulfurization. [EMMOR][SCN] proved to be the most viable IL for the removal of all the three aromatic sulfur compounds.

11/02478 Desulfurization of diesel fuels by selective adsorption on activated carbons: competitive adsorption of polycyclic aromatic sulfur heterocycles and polycyclic aromatic hydrocarbons

Bu, J. *et al. Chemical Engineering Journal*, 2011, 166, (1), 207–217.

Adsorptive affinity of polycyclic aromatic sulfur heterocycles (PASHs) and polycyclic aromatic hydrocarbons (PAHs) on activated carbons and the effect of PAHs on the adsorption performance of PASHs were studied. Adsorptions of real and model diesels (MDs) containing aromatics and sulfur compounds over several activated carbons were conducted in both batch and fixed-bed adsorption systems. The adsorption results showed that adsorptive affinities of molecules with polycyclic aromatic skeleton structure are primarily governed by the π–π dispersive interaction between the aromatic rings and the graphene layers of activated carbons. In addition, the electron donor–acceptor mechanism also plays an important role for S-containing molecules. Furthermore, for effective adsorption of large molecules, not only the pore size of the adsorbent should be, at least, larger than the critical diameter of the adsorbate, but also the pore size should also be sufficiently large to reduce diffusional resistance during adsorption. Based on this studies, it can be concluded that the adsorption selectivity increases as follows: naphthalene < fluorene < dibenzothiophene < 4,6-dimethyl dibenzothiophene < anthracene < phenanthrene. The adsorption capacity of PASHs decreases significantly in the presence of PAHs as result of the adsorption competition due to similar structure, molecular diameter and adsorption mechanisms.

11/02479 Gasoline alkylation desulfurization over Amberlyst 35 resin: influence of methanol and apparent reaction kinetics

Guo, B. *et al. Fuel*, 2011, 90, (2), 713–718.

Gasoline desulfurization is receiving attention worldwide due to the increasing stringent regulations on sulfur content for environmental protection purpose. As conventional hydrotreating technology leads to significant octane number loss and processing costs, the gasoline alkylation desulfurization process, which consists of weighing down the sulfuric compounds by catalytic alkylation with olefins present in the feed and distillation followed by, is a rather attractive way. In this paper, firstly alkylation of thiophenic compounds was researched over macroporous sulfonic resin Amberlyst 35 in methanol presence to increase the selectivity of catalyst, then kinetics of thiophenic sulfurs alkylation in FCC gasoline was researched without and with methanol. Results found that appropriate methanol ($\leq$2 wt% methanol in model gasoline and $\leq$1 wt% methanol in FCC gasoline) could inhibit olefins oligomerization significantly without influence on the conversions of thiophenic compounds. The alkylation of thiophenic sulfurs could be described as pseudo first-order reaction regardless of the existence of methanol. The introduction of methanol decreases the reaction rate constant and increases the activation energy of alkylation reactions.

11/02480 Oxidative desulfurization of diesel with TBHP/isobutyl aldehyde/air oxidation system

Guo, W. *et al. Applied Energy*, 2011, 88, (1), 175–179.

Oxidative desulfurization of hydrogenation diesel (40 mL) was studied using air as oxidant, tert-butyl hydroperoxide (TBHP) as radical initiator at ambient pressure and moderate temperature in the presence of isobutyl aldehyde. TBHP could accelerate the production of carbonyl radical and its peroxidation. When the molar fraction of

TBHP was 5 mmol, the conversion of DBT could reach 96.1% in the present of 20 mmol isobutyl aldehyde and air, which was more than that of 85.5% without initiator. The air was an effective oxidant and acetonitrile was an optimal solvent in this process. The sulfur content of the hydrogenation diesel could be reduced from 403 to 13 ppm (96.8% removed) under the synergistic effect of air, TBHP and isobutyl aldehyde.

11/02481 Transportation of heavy and extra-heavy crude oil by pipeline: a review

Martínez-Palou, R. *et al. Journal of Petroleum Science and Engineering*, 2011, 75, (3–4), 274–282.

The transportation of heavy and extra-heavy crude oils from the head-well to the refinery is becoming important since their production is currently rising all over the world. Such oils are characterized by a low API gravity (<20) and high viscosity (>10^3 cP at 298.15 K) that render difficult oil flow through pipelines. Conventional technology pipelining is designed for light and medium oil crudes, but the pipelining of heavy and extra-heavy crude oils may be challenging because of their high viscosities, asphaltene and paraffin deposition, increasing content of formation water, salt content and corrosion issues. In this paper, the current and innovative technological solutions covering viscosity and friction reduction to move such crude oils from the production site to the processing facilities are thoroughly discussed.

Economics, business, marketing, policy

11/02482 A dynamic hedging approach for refineries in multiproduct oil markets

Ji, Q. and Fan, Y. *Energy*, 2011, 36, (2), 881–887.

A multiproduct portfolio hedge ratio strategy for oil futures is investigated using a multivariate GARCH model based on dynamic conditional correlation and an error correction model (DCC-ECM-MVGARCH). By considering the characteristics of refiner profits from crack spread and the mutual relations among crude oil, gasoline and heating oil spot and future prices, the time-varying optimal hedge ratios for the oil-cracking margin were estimated. In addition, a naive strategy, a traditional ordinary least squares model and dynamic B-GARCH model are selected to compare with the model for hedge effectiveness. Comparison of hedge effectiveness for in-sample and out-of-sample data reveals that the dynamic DCC-ECM-MVGARCH model is more sensitive to market fluctuations, provides a more accurate description of changes in volatility and has more advantages than other models. Therefore, the empirical results prove that application of the DCC-ECM-MVGARCH model for hedging of oil market portfolio can play an important role in avoiding the double risk of crude oil and oil product markets for refineries.

11/02483 An adaptively scaled frequency-domain parameterization for history matching

Bhark, E. *et al. Journal of Petroleum Science and Engineering*, 2011, 75, (3–4), 289–303.

History matching problems are typically underdetermined and are at once confronted with the problems of solution non-uniqueness, instability, and the ability to both reproduce field observations and provide a reliable forecast. The authors address these challenges with a new adaptive multiscale history matching formulation that parameterizes the reservoir properties in the frequency domain. The geologic model updating is carried out by successively increasing the level of detail up to a spatial scale sufficient to match the observed data. The method begins by constructing a coarse representation of the field using the lowest-frequency components of its discrete cosine parameterization. This substantially reduces the number of unknown parameters to be resolved during history matching, leading to a better posed inverse problem. A gradient-based minimization is then performed to match the production data. Next, the updated model is incrementally refined in the frequency domain and the minimization is repeated until the data misfit is reduced below a pre-specified criterion or until no further improvements are observed. During minimization, components of the gradient insensitive to production information are removed by a truncated singular value decomposition (TSVD), facilitating iterative convergence and providing additional regularization. In this manner a balance is achieved between parameter reduction which is required for stability, and the spatial resolution of heterogeneity required for reproduction of the production history. The low-frequency approximation of the permeability field helps to honour geologic continuity and is particularly suited for resolving the large-scale heterogeneity that has a dominant influence on the field-scale flow regime and production response. Applications of the approach are demonstrated using the SPE10 and PUNQ-S3 models and involve waterflood history matching with water-cut and bottom-hole pressure data. The results show that the principle geologic features of the reference field are adequately resolved only if beginning at low resolution. As the resolution is iteratively increased, the history match is improved while the TSVD step removes insensitive parameter combinations thereby decreasing the likelihood of convergence to less plausible local minima. Notably, in all the applications an adequate history match is achieved using less than 1% of the original parameter dimension, which leads to increased solution stability and computational savings in history matching large geologic models.

11/02484 An analysis of oil production by OPEC countries: persistence, breaks, and outliers

Barros, C. P. *et al. Energy Policy*, 2011, 39, (1), 442–453.

This study examines the time series behaviour of oil production for OPEC member countries within a fractional integration modelling framework recognizing the potential for structural breaks and outliers. The analysis is undertaken using monthly data from January 1973 to October 2008 for 13 OPEC member countries. The results indicate there is mean reverting persistence in oil production with breaks identified in 10 out of the 13 countries examined. Thus, shocks affecting the structure of OPEC oil production will have persistent effects in the long run for all countries, and in some cases the effects are expected to be permanent.

11/02485 An energy-saving oil drilling rig for recovering potential energy and decreasing motor power

Zhang, L. *Energy Conversion and Management*, 2011, 52, (1), 359–365.

An energy-saving oil drilling rig is researched. A large accumulator is adopted in this rig to store the energy of the motor during the auxiliary time of lifting the drill stem and the potential energy of the drill stem when lowered. The equipped power of this rig decreases remarkably compared with the conventional drilling rig, and this rig can also recover and reuse the potential energy of the drill stem. Therefore, this rig owns remarkable energy-saving effect compared with the conventional drilling rig, and the energy-saving effect of the energy-saving oil drilling rig is also verified by the field tests. The mathematical model of the energy-saving oil drilling rig lowering the drill stem was derived and simulation analysis was conducted. Through simulation the curves of the drill stem lowering velocity and lowering displacement with time were obtained, and some conclusions were reached: (1) the heavier the drill stem lowered, the higher the lowering velocity is, and the shorter the lowering time is; (2) the smaller the displacement of the variable pump-motor, the higher the lowering velocity is, and the shorter the lowering time is.

11/02486 Co-integration of ICE gas oil and crude oil futures

Westgaard, S. *et al. Energy Economics*, 2011, 33, (2), 311–320.

In this paper, the relationship between gas oil and Brent crude oil futures prices is investigated. The analysis is based on daily price series for five different contract lengths traded on ICE Futures Europe. The price series and their first differences are tested for stationarity. Linear relationships between the pair-wise gas oil and crude oil contracts are then tested for co-integration. A co-integrated relationship is found for the 1- and 2-month contracts covering data from 1994 to 2009, and error correction models are established to estimate the relationships. No co-integrated relationships are found for the 3-, 6- and 12-month contracts covering the period 2002–2009, nor for the 1- and 2-month contracts for this period. The futures prices for this period are collected from a volatile market, including hurricane Katrina, the economic boom and the following financial crises which might explain these results. Thus, in such volatile periods the spread between gas oil and crude oil is likely to deviate, and it might take several years until it reverts to its equilibrium value. For energy traders and hedgers, this will imply that exposures to the crack spread should be treated with great care in such market environments.

11/02487 Competitive liquid biofuels from biomass

Demirbas, A. *Applied Energy*, 2011, 88, (1), 17–28.

The cost of biodiesels varies depending on the feedstock, geographic area, methanol prices, and seasonal variability in crop production. Most of the biodiesel is currently made from soybean, rapeseed, and palm oils. However, there are large amounts of low-cost oils and fats (e.g. restaurant waste, beef tallow, pork lard, and yellow grease) that could be converted to biodiesel. The crop types, agricultural practices, land and labour costs, plant sizes, processing technologies and government policies in different regions considerably vary ethanol production costs and prices by region. The cost of producing bioethanol in a dry mill plant currently totals US$1.65/gallon. The largest ethanol cost component is the plant feedstock. It has been showed that plant size has a major effect on cost. The plant size can reduce operating costs by 15–20%, saving another $0.02–0.03 per litre. Thus, a large plant with production costs of $0.29 per litre may be saving $0.05–0.06 per litre over a smaller plant. Viscosity of biofuel and biocrude varies greatly with the liquefaction conditions. The high and increasing viscosity indicates a poor flow characteristic and stability.

The increase in the viscosity can be attributed to the continuing polymerization and oxidative coupling reactions in the biocrude upon storage. Although stability of biocrude is typically better than that of bio-oil, the viscosity of biocrude is much higher. The bio-oil produced by flash pyrolysis is a highly oxygenated mixture of carbonyls, carboxyls, phenolics and water. It is acidic and potentially corrosive. Bio-oil can also be potentially upgraded by hydrodeoxygenation. The liquid, termed biocrude, contains 60% carbon, 10–20 wt% oxygen and 30–36 MJ/kg heating value as opposed to <1 wt% and 42–46 MJ/kg for petroleum.

11/02488 Economics of oil regulation and the Brazilian reform: some issues

Hernandez-Perez, A. *Energy Policy*, 2011, 39, (1), 57–65.

This paper reviews the economic fundamentals for regulation in the oil industry, with a focus on the current regulatory proposal for the Brazilian oil industry. The observed exploration and production (E&P) contracts foresee much of the characteristics of the optimal contract, with a remuneration structure that combines upfront with future payments to mitigate uncertainty and incentivize exploratory efforts. In Brazil, despite slow market deconcentration since 1997's liberalization, the current oil regulation is in general consistent with an optimal regulatory response. From an economic standpoint, the 2009's new regulatory proposal prompted by the major oil discoveries offshore in Brazil reduces the power of incentive schemes with respect to exploratory and cost-reducing efforts while the changes in the net risk of the E&P offshore activities are not so clear.

11/02489 Forecasting petroleum consumption in China: comparison of three models

Ji, L.-Q. *Journal of the Energy Institute*, 2011, 84, (1), 34–37.

This paper investigates the effectiveness of the four-parameter logistic model, the Gompertz–Laird model and the stochastic Gompertz innovation diffusion model for describing the evolution of petroleum consumption in China. The three sigmoidal growth models are applied to the historical data on petroleum consumption in China. The developed models are compared using the goodness-of-fit to the historical data. The selected statistical measures are the coefficient of determination R^2, the mean squared error, the mean absolute percentage error, the mean absolute deviation and the Durbin–Watson statistic d. The good model fit has indicated that the four-parameter logistic model is a very appropriate candidate in forecasting petroleum consumption in China.

11/02490 Gold and oil futures markets: are markets efficient?

Narayan, P. K. *et al. Applied Energy*, 2010, 87, (10), 3299–3303.

This study examines the long-run relationship between gold and oil spot and futures markets. The authors draw on the conceptual framework that when oil price rises, it creates inflationary pressures, which instigate investments in gold as a hedge against inflation. The long-run relationship between gold and oil futures prices was tested at different maturity and evidence was found of cointegration. This implies that: (a) investors use the gold market as a hedge against inflation and (b) the oil market can be used to predict the gold market prices and vice versa, thus these two markets are jointly inefficient, at least for the sample period considered in this study.

11/02491 11/02491 Iran fights sanctions with $150 bn production plan

Anon., *Oil and Energy Trends*, 2011, 36, (2), 3–6.

Despite worldwide financial and trade sanctions, Iran has announced a 5-year plan to increase oil production and to maximize its oil exports.

11/02493 Oil and resource-backed aggression

Colgan, J. *Energy Policy*, 2011, 39, (3), 1669–1676.

A common misperception about oil politics is that it has a uniform, monolithic effect on policy development. This paper argues that in fact the net political effect of oil varies dramatically depending on the nature of the petrostate. It shows that oil income, when combined with revolutionary governments in petrostates, generates strong incentives for foreign policy aggression and international conflict. The aggressiveness of petro-revolutionary states is shown to have consequences in both military and economic spheres of international relations. Militarily, the aggressiveness of this type of state leads to a high rate of armed conflicts. Economically, the aggressiveness of petro-revolutionary states shapes global oil markets and international economic relations. The argument is tested using statistical analysis of international conflicts and economic sanctions. The policy implications are then considered, focusing on the negative global impacts of dependence on oil consumption.

11/02494 Oil price cycles and wavelets

Naccache, T. *Energy Economics*, 2011, 33, (2), 338–352.

The present paper addresses the question of the oil price–macroeconomy relationship using world data and a time scale decomposition based on the theory of wavelets. The approach is based on a global indicator, the Morgan Stanley Capital International (MSCI) index for the world, and on the new framework offered by wavelets to analyse the oil price cycles and to investigate the oil price–MSCI relationship. This original approach enables us to identify that the cycles which contribute the most to oil price variations are 20- to 40-year cycles, which correspond to the size of Kuznets infrastructure cycles and probably represent energy investment cycles. This wavelet decomposition also provides additional evidence to the 'reverse causality' theory.

11/02495 Peak oil analyzed with a logistic function and idealized Hubbert curve

Gallagher, B. *Energy Policy*, 2011, 39, (2), 790–802.

A logistic function is used to characterize peak and ultimate production of global crude oil and petroleum-derived liquid fuels. Annual oil production data were incrementally summed to construct a logistic curve in its initial phase. Using a curve-fitting approach, a population-growth logistic function was applied to complete the cumulative production curve. The simulated curve was then deconstructed into a set of annual oil production data producing an 'idealized' Hubbert curve. An idealized Hubbert curve (IHC) is defined as having properties of production data resulting from a constant growth-rate under fixed resource limits. An IHC represents a potential production curve constructed from cumulative production data and provides a new perspective for estimating peak production periods and remaining resources. The IHC model data show that idealized peak oil production occurred in 2009 at 83.2 Mb/d (30.4 Gb/y). IHC simulations of truncated historical oil production data produced similar results and indicate that this methodology can be useful as a prediction tool.

11/02496 Recent progress in the development of diesel surrogate fuels

Pitz, W. J. and Mueller, C. J. *Progress in Energy and Combustion Science*, 2011, 37, (3), 330–350.

There has been much recent progress in the area of surrogate fuels for diesel. In the past few years, experiments and modelling have been performed on higher molecular weight components of relevance to diesel fuel such as n-hexadecane (n-cetane) and 2,2,4,4,6,8,8-heptamethylnonane (iso-cetane). Chemical kinetic models have been developed for all the n-alkanes up to 16 carbon atoms. Also, there has been experimental and modelling work on lower molecular weight surrogate components such as n-decane and n-dodecane that are most relevant to jet fuel surrogates, but are also relevant to diesel surrogates where simulation of the full boiling point range is desired. For two-ring compounds, experimental work on decalin and tetralin recently has been published. For esters, kinetic mechanisms for compounds of lower molecular weights but similar to those found in typical biodiesel blendstocks also have been published. For multi-component surrogate fuel mixtures, recent work on modelling of these mixtures and comparisons to real diesel fuel is reviewed. Detailed chemical kinetic models for surrogate fuels are very large in size, so it is noteworthy that significant progress also has been made in improving the mechanism reduction tools that are needed to make these large models practicable in multi-dimensional reacting flow simulations of diesel combustion. Nevertheless, major research gaps remain. In the case of iso-alkanes, there are experiments and modelling work on only one of relevance to diesel: iso-cetane. Also, the iso-alkanes in diesel are lightly branched and no detailed chemical kinetic models or experimental investigations are available for such compounds. More components are needed to fill out the iso-alkane boiling point range. For the aromatic class of compounds, there has been little work for compounds in the boiling point range of diesel. Most of the new work has been on alkyl aromatics that are of the range C7–C9, below the C10–C20 range that is needed. For the chemical classes of cycloalkanes and esters, experiments and modelling on higher molecular weight components are warranted. Finally for multi-component surrogates needed to treat real diesel, the inclusion of higher molecular weight components is needed in models and experimental investigations.

11/02497 Speculation and volatility spillover in the crude oil and agricultural commodity markets: a Bayesian analysis

Du, X. *et al. Energy Economics*, 2011, 33, (3), 497–503.

This paper assesses factors that potentially influence the volatility of crude oil prices and the possible linkage between this volatility and agricultural commodity markets. Stochastic volatility models are applied to weekly crude oil, corn, and wheat futures prices from November 1998 to January 2009. Model parameters are estimated using Bayesian Markov chain Monte Carlo methods. Speculation, scalping, and petroleum inventories are found to be important in explaining the volatility of crude oil prices. Several properties of crude oil price dynamics are established, including mean-reversion, an asymmetry between returns and volatility, volatility clustering, and infrequent compound jumps. The authors find evidence of volatility spillover among crude oil, corn, and wheat markets after the fall of 2006. This can be largely explained by tightened interdependence between crude oil and these commodity markets induced by ethanol production.

11/02498 The effect of population density, road network density, and congestion on household gasoline consumption in U.S. urban areas

Su, Q. *Energy Economics*, 2011, 33, (3), 445–452.
This paper applies both semiparametric and parametric approaches to explore the effect of population density, freeway road density, and congestion on household gasoline consumption in US urban areas while controlling for household demographic and economic characteristics. Regression results indicate that households living in those urban areas with higher freeway densities, higher levels of congestion, or lower population densities consume more gasoline.

11/02499 The influence of organic and inorganic fertiliser application rates on UK biomass crop sustainability

Gilbert, P. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1170–1181.
Bioenergy and energy crops are an important part of the UK's renewable energy strategy to reach its greenhouse gas reduction target of 80% by 2050. Ensuring the sustainability of biomass feedstocks requires a greater understanding of all aspects of energy crop production, their ecological impacts and yields. This work compares the life-cycle environmental impact of natural gas and biomass from two energy crop systems grown under typical UK agronomic practice. As reported in previous studies the energy crops provide significant reductions in global warming potential (GWP) compared to natural gas. Compared to no fertilizer application, applying inorganic fertilizer increases the GWP by 2% and applying sewage sludge increases the GWP by a lesser extent. In terms of an equivalent GWP savings per unit area of land, the emissions associated with fertilizer production and application can be offset by a yield increase of <0.2 t/ha. However, very large increases in eutrophication and acidification levels are incurred compared to the natural gas reference case when applying either fertilizer. For sewage sludge the impact of varying the allocation factor between the function of wastewater treatment and that of crop growth is also illustrated.

11/02500 The role of market fundamentals and speculation in recent price changes for crude oil

Kaufmann, R. K. *Energy Policy*, 2011, 39, (1), 105–115.
The author hypothesizes that the price spike and collapse of 2007–2008 are driven by both changes in both market fundamentals and speculative pressures. Contrary to arguments for a demand shock, the author goes on to hypothesize that prices rise sharply in 2007–2008 because ongoing growth in Chinese oil demand runs into a sudden and unexpected halt to a decade long increase in non-OPEC production. This caused a loss of OPEC spare capacity because increased demand for OPEC production runs ahead of increases in OPEC capacity. These changes are reinforced by speculative expectations. Although difficult to measure directly, the author argues for the role of speculation based on the following: (1) a significant increase in private US crude oil inventories since 2004; (2) repeated and extended break-downs (starting in 2004) in the cointegrating relationship between spot and far month future prices that are inconsistent with the law of one price and arbitrage opportunities; and (3) statistical and predictive failures by an econometric model of oil prices that is based on market fundamentals. These changes are related to the behaviour and impact of noise traders on asset prices to sketch mechanisms by which speculative expectations can affect crude oil prices.

11/02501 Volatility spillover from world oil spot markets to aggregate and electricity stock index returns in Turkey

Soytas, U. and Oran, A. *Applied Energy*, 2011, 88, (1), 354–360.
This study examines the inter-temporal links between world oil prices, ISE 100 and ISE electricity index returns unadjusted and adjusted for market effects. The traditional approaches could not detect a causal relationship running from oil returns to any of the stock returns. However, when the causality was examined using Cheung–Ng approach it was discovered that world oil prices Granger cause electricity index and adjusted electricity index returns in variance, but not the aggregate market index returns. Hence, the results show that the Cheung–Ng procedure with the use of disaggregated stock index returns can uncover new information that went unnoticed with the traditional causality tests using aggregated market indices.

11/02502 World oil prices and agricultural commodity prices: evidence from an emerging market

Nazlioglu, S. and Soytas, U. *Energy Economics*, 2011, 33, (3), 488–496.
Oil prices are thought to have direct effect on agricultural prices followed by an indirect effect through the exchange rate. This paper examines the short- and long-run interdependence between world oil prices, lira–dollar exchange rate, and individual agricultural commodity prices (wheat, maize, cotton, soybeans, and sunflower) in Turkey. To this end, the Toda–Yamamoto causality approach and generalized impulse–response analysis for identification of the long- and short-run interrelationships are applied to the monthly data spanning from January 1994 to March 2010. The impulse–response analysis suggests the Turkish agricultural prices do not significantly react to oil price and exchange rate shocks in the short-run. The long-run causality analysis reveals that the changes in oil prices and appreciation/depreciation of the Turkish lira are not transmitted to agricultural commodity prices in Turkey. Hence, the results support neutrality of agricultural commodity markets in Turkey to both direct and indirect effects of oil price changes.

Derived liquid fuels

11/02503 A single step methane conversion into synthetic fuels using microplasma reactor

Nozaki, T. *et al. Chemical Engineering Journal*, 2011, 166, (1), 288–293.
Direct conversion of natural gas into synthetic fuels such as methanol attracts keen attention because direct process can reduce capital and operating costs of high temperature, energy intensive, multi-step processes. The authors report a direct and selective synthesis of organic oxygenates such as methanol, formaldehyde, and formic acid via methane partial oxidation at room temperature using non-thermal discharge microreactor. Heat generated by methane partial oxidation is removed efficiently in the microreactor configuration: liquid components are condensed on the reactor wall and separated from O_2-rich reactive plasma, enabling selective synthesis of oxygenates while high methane conversion is achieved in a single reactor. As a result, organic oxygenates were synthesized with one-pass yield of 5–20% with 70–30% selectivity. In addition to oxygenates, syngas was produced with selectivity of 40% and $H_2/CO = 1$. Assuming one-step catalytic DME synthesis as a post-discharge process, one-pass liquid yield of 30% with 80% selectivity is feasible.

11/02504 Calcium-based mixed oxide catalysts for methanolysis of *Jatropha curcas* oil to biodiesel

Taufiq-Yap, Y. H. *et al. Biomass and Bioenergy*, 2011, 35, (2), 827–834.
Calcium-based mixed oxides catalysts (CaMgO and CaZnO) have been investigated for the transesterification of *Jatropha curcas* oil (JCO) with methanol, in order to evaluate their potential as heterogeneous catalysts for biodiesel production. Both CaMgO and CaZnO catalysts were prepared by coprecipitation method of the corresponding mixed metal nitrate solution in the presence of a soluble carbonate salt at approximately pH8–9. The catalysts were characterized by X-ray diffraction (XRD), temperature programmed desorption of CO_2 (CO_2-TPD), scanning electron microscopy and N_2 adsorption. The conversion of JCO by CaMgO and CaZnO were studied and compared with calcium oxide (CaO), magnesium oxide (MgO) and zinc oxide (ZnO) catalysts. Both CaMgO and CaZnO catalysts showed high activity as CaO and were easily separated from the product. CaMgO was found more active than CaZnO in the transesterification of JCO with methanol. Under the suitable transesterification conditions at 338 K (catalyst amount = 4 wt%, methanol/oil molar ratio = 15, reaction time = 6 h), the JCO conversion of more than 80% can be achieved over CaMgO and CaZnO catalysts. Even though CaO gave the highest activity, the conversion of JCO decreased significantly after reused for forth run whereas the conversion was only slightly lowered for CaMgO and CaZnO after sixth run.

11/02505 Catalytic cracking of squalene to gasoline-range molecules

Tracy, N. I. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1060–1065.
Cracking squalene over a zeolite catalyst produced an organic liquid containing light hydrocarbons. The distillate of the organic liquid product (boiling point of less than 275 °C) was analysed by ASTM gasoline methods and found to have a research octane number of 98.

11/02506 Catalytic upgrading of oil fractions separated from food waste leachate

Heo, H. S. *et al. Bioresource Technology*, 2011, 102, (4), 3952–3957.
In this work, catalytic cracking of biomass waste oil fractions separated from food waste leachate was performed using microporous catalysts, such as HY, HZSM-5 and mesoporous Al-MCM-48. The experiments were carried out using pyrolysis gas chromatography/mass spectrometry (Py-GC/MS) to allow the direct analysis of the pyrolytic products. Most acidic components, especially oleic acid, contained in the food waste oil fractions were converted to valuable products, such as oxygenates, hydrocarbons and aromatics. High yields of hydro-

carbons within the gasoline-range were obtained when microporous catalysts were used; whereas, the use of Al-MCM-48, which exhibits relatively weak acidity, resulted in high yields of oxygenated and diesel-range hydrocarbons. The HZSM-5 catalyst produced a higher amount of valuable mono aromatics due to its strong acidity and shape selectivity. Especially, the addition of gallium to HZSM-5 significantly increased the aromatics content.

11/02507 Co-liquefaction of lignite and sawdust under syngas

Guo, Z. *et al. Fuel Processing Technology*, 2011, 92, (1), 119–125.

Individual and co-liquefaction of lignite and sawdust (CLLS) under syngas was performed in an autoclave and the effects of temperature, initial syngas pressure, reaction time and ratio of solvent to coal and biomass on the product distribution of CLLS were studied. Sawdust is easier to be liquefied than lignite and the addition of sawdust promotes the liquefaction of lignite. There is some positive synergetic effect during CLLS. In the range of the experimental conditions investigated, the oil yield of CLLS increases with the increase of temperature, reaction time (10–30 min) and the ratio of the solvent to the feedstock (0–3), but varies little with the increase of initial syngas pressure. Accordingly, the total conversion, the yield of preasphaltene and asphaltene (PA + A) and gas, changes by the difference in operation conditions of liquefaction. The gas products are mainly CO and CO_2 with a few C_1–C_4 components. The syngas can replace the pure hydrogen during CLLS. The optimized operation conditions in the present work for CLLS are as follows: syngas, temperature 360 °C, initial cold pressure 3.5 MPa, reaction time 30 min, the ratio of solvent to coal and sawdust 3:1. Water gas shift reaction occurs between CO in the syngas and water from coal and sawdust moisture during the co-liquefaction, producing the active hydrogen which increases the conversion of liquefaction and decreases the hydrogen consumption.

11/02508 Determining the anisotropic content in a petroleum pitch – comparison of centrifugation and optical microscopy techniques

Vieira, F. R. *et al. Fuel*, 2011, 90, (2), 908–911.

The anisotropic content of a pitch is one of the most important parameters for characterizing such materials. Polarized light optical microscopy is the technique most commonly employed (ASTM D 4616 standard procedure) to measure this pitch parameter. However, this standard procedure is limited to pitches with mesophase contents only up to 20%. An alternative technique for determining the anisotropic content of a pitch is high-temperature centrifugation, which can be used without limitation for pitches with up to 100% anisotropic content. In this work, the two techniques have been compared; samples of four pitches with mesophase contents lower than 20% have been analysed by both techniques and the results have been compared. The high-temperature centrifugation technique showed good repeatability, and the results that it yielded matched those obtained from optical microscopy when the anisotropic content of the pitch was higher than around 5%. The centrifugation technique is always faster, simpler, and possibly more accurate than optical microscopy for pitches with mesophase contents higher than 20%.

11/02509 Experimental study on methanol recovery through flashing vaporation in continuous production of biodiesel via supercritical methanol

Wang, C. *et al. Energy Conversion and Management*, 2011, 52, (2), 1454–1458.

To improve the oil conversion, high methanol/oil molar ratio is required in the continuous production of biodiesel via supercritical methanol transesterification in tubular reactor. And thus the subsequent excess methanol recovery needs high energy consumption. Based on the feature of high temperature and high pressure in supercritical methanol transesterification, excess methanol recovery in reaction system by flashing vaporation is conducted and the effect of reaction temperature, reaction pressure and flashing pressure on methanol recovery and methanol concentration in gas phase is discussed in detail in this article. Results show that at the reaction pressure of 9–15 MPa and the reaction temperature of 240–300 °C, flashing pressure has significant influence on methanol recovery and methanol content in gas phase, which can be effectively improved by reducing flashing pressure. At the same time, reaction temperature and reaction pressure also have an important effect on methanol recovery and methanol content in gas phase. At volume flow of biodiesel and methanol 1:2, tubular reactor pressure 15 MPa, tubular reactor temperature 300 °C and the flashing pressure 0.4 MPa, methanol recovery is more than 85% and methanol concentration of gas phase (mass fraction) is close to 99% after adiabatic braising; therefore, the condensate liquid of gas phase can be injected directly into methanol feedstock tank to be recycled.

11/02510 TBP and chromatographic data for gas condensates characterisation

Hosein, R. and Dawe, R. A. *Journal of Petroleum Science and Engineering*, 2011, 75, (3–4), 283–288.

Gas condensate fluids require accurate characterization for use in the equations of state used in reservoir modelling for field development planning. The most useful data for the computations are determined from single carbon number (SCN) fractions which are obtained by true boiling point (TBP) distillations and high precision gas chromatography (GC). TBP analysis requires careful calibration and operation to minimize the amount of overlap outside the boiling range of the fraction. Tests conducted with a TBP apparatus using mixtures of pure components showed differences of mainly less than 3% between the weight per cent of the separated components and the original weight per cent of the pure components in the mixture. The TBP gives separated fluids which can be used to determine specific gravity, molecular weight and other PVT information. GC analysis cannot provide these data, but provides a more precise analysis of SCN composition than the TBP. The limited data available in the open literature for comparison can show differences ranging up to 30% due to imperfect separation by TBP. However the authors obtained differences of mainly less than 8%. The relative closeness of SCN composition allows the use of the high precision GC for benchmarking results from TBP. The SCN weight average boiling points determined from TBP and GC data showed differences of less than 0.5% which further validate the quality of SCN fractions that can be derived by TBP and which can be used in gas condensates characterization studies where experimental data are unavailable.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

11/02511 A geochemical study on mud volcanoes in the Junggar Basin, China

Nakada, R. *et al. Applied Geochemistry*, 2011, 26, (7), 1065–1076.

A comprehensive study was performed to characterize, for the first time, the mud, water, and gases released from onshore mud volcanoes located in the southern margin of the Junggar Basin, north-western China. Chemical compositions of mud, along with the geology of the basin, suggest that a source of the mud is Mesozoic or Cenozoic shale. Oxygen and H isotope compositions of the released water suggest a local meteoric origin. Combined with the positive Eu anomalies of the water, a large ^{18}O shift of the water suggests extensive interaction with rocks. Gases discharged from the mud volcanoes are predominantly thermogenic hydrocarbons, and the high $\delta^{13}C$ values (> +20‰ VPDB) for CO_2 gases and dissolved carbonate in muddy water suggest secondary methanogenesis with CO_2 reduction after oil biodegradation. The enrichments of Eu and ^{18}O in water and the low thermal gradient of the area suggest that the water–rock interactions possibly occur deeper than 3670 ± 200 m. On the other hand, considering the relationship to the petroleum reservoir around the mud volcanoes, the depth of the gases can be derived from about 3600 m, a depth that is greater than that generally estimated for reservoirs whose gas is characterized by ^{13}C-enriched CO_2. Oil biodegradation with CO_2 reduction likely occurs at a shallower depth along the seepage system of the mud volcano. The results contribute to the worldwide data set of gas genesis in mud volcanoes. Moreover, they further support the concept that most terrestrial mud volcanoes release thermogenic gas produced in very deep sediments and may be early indicators of oil biodegradation, an important problem in the petroleum industry.

11/02512 Coalbed methane resources assessment in Asturias (Spain)

Cienfuegos, P. and Loredo, J. *International Journal of Coal Geology*, 2010, 83, (4), 366–376.

The Asturian central coal basin, located in northern Spain, is the most important coal basin in the Iberian peninsula and some antecedents for coalbed methane exploration on this basin go back to the beginning of the 1990s, when two deep wells were drilled in selected areas of the basin. This paper contains the results of preliminary studies, accomplished from 2003 to 2006, that focused on the potential of the Asturian central coal basin for the development of coalbed methane projects. According to these studies, the gas content in coal beds approximately ranges from 3.88 to 10.81 m^3/t (ash free), and coalbed methane resources in the coal basin has been estimated in a minimum value of 25,100 Mm^3. Despite the fact that the gas content in the entire coal basin is modest, it appears to be adequate for a commercial coalbed methane development, although it is limited by the size of the basin. The option for implementation of coalbed methane projects in this basin is associated to the application of a non-traditional programme for coalbed methane development, including the use of directional drilling from a limited number of well sites. Carbon dioxide sequestration could be associated with the recuperation of methane from the unexploited coal beds.

11/02513 Computational fluid dynamic simulations of chemical looping fuel reactors utilizing gaseous fuels

Mahalatkar, K. *et al. Chemical Engineering Science*, 2011, 66, (3), 469–479.

A computational fluid dynamic (CFD) model for the fuel reactor of chemical looping combustion technology has been developed, with special focus on accurately representing the heterogeneous chemical reactions. A continuum two-fluid model was used to describe both the gas and solid phases. Detailed sub-models to account for fluid–particle and particle–particle interaction forces were also incorporated. Simulations were carried out to test the capability of the CFD model to capture changes in outlet gas concentrations with changes in number of parameters such as superficial velocity, metal oxide concentration, reactor temperature, etc. Detailed time varying outlet concentration values were compared with other studies, and it was found that CFD simulations provided a reasonable match with these data.

11/02514 Effect of scale on the explosion of methane in air and its shockwave

Zhang, Q. *et al. Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 43–48.

Explosion experiments using premixed gas in a duct have become a significant method of investigating methane–air explosions in underground coal mines. The duct sizes are far less than that of an actual mine gallery. Whether the experimental results in a duct are applicable to analyse a methane–air explosion in a practical mine gallery needed to be investigated. This issue involves the effects of scale on a gas explosion and its shockwave in a constrained space. The commercial software package AutoReaGas, a finite element computational fluid dynamics code suitable for gas explosions and blast problems, was used to carry out the numerical simulation for the explosion processes of a methane–air mixture in the gallery (or duct) at various scales. Based on the numerical simulation and its analysis, the effect of scale on the degree of correlation with the real situation was studied for a methane–air explosion and its shockwave in a square-section gallery (or duct). This study shows that the explosion process of the methane–air mixture relates to the scales of the gallery or duct. The effect of scale decreases gradually with the distance from the space containing the methane–air mixture and the air shock wave propagation conforms approximately to the geometric similarity law in the far field where the scaled distance [ratio of the propagation distance and the height (or width) of the gallery section] is over 80.

11/02515 Integration of SEWGS for carbon capture in natural gas combined cycle. Part A: thermodynamic performances

Manzolini, G. *et al. International Journal of Greenhouse Gas Control*, 2011, 5, (2), 200–213.

This two-part paper investigates the performance of different integration options of an innovative reactor for CO_2 capture named SEWGS (sorption-enhanced water gas shift) in a natural gas combined cycle. This activity was carried out under the FP7 project CAESAR financed by the EU. In part A, several plant layouts starting from a completely decoupled hydrogen island and power section, up to very tight integration are investigated in order to outline mutual advantages and performances. Decoupling the hydrogen island from the power plant is beneficial to system flexibility but penalizes the net electric efficiency (45.9% with a CO_2 capture of 95.3%). The best overall performance is achieved by a tight integration of the two sections that increases efficiency up to 50.9% with a CO_2 capture of 95.2%, thanks also to the possibility of expanding the CO_2–steam stream from the SEWGS unit. A sensitivity analysis on the main parameters is also carried out. Part B presents three reference cases selected for electricity production with and without CO_2 capture in order to benchmark the innovative solution including by exergy analysis.

11/02516 Integration of SEWGS for carbon capture in natural gas combined cycle. Part B: reference case comparison

Manzolini, G. *et al. International Journal of Greenhouse Gas Control*, 2011, 5, (2), 214–225.

This two-part paper investigates the performance of different integration possibilities in a natural gas combined cycle of an innovative reactor for CO_2 capture named SEWGS (sorption enhanced water gas shift). This activity is carried out under the FP7 project CAESAR financed by the EU. In part A, several plant layouts starting from completely decoupled hydrogen island and power section up to very tight integration are investigated in order to show the different advantages and performance differences. A sensitivity analysis on main parameters is also carried out. Part B presents three reference cases selected for electricity production: without carbon capture, with post-combustion carbon capture by MEA and with pre-combustion carbon capture by MDEA. These cases are compared with three different SEWGS plants presented in part A. A tight integration between power and hydrogen island allows SEWGS to achieve a lower efficiency penalty than MEA and MDEA (7.5% for SEWGS, 8.4% for MEA and 8.0% for MDEA) with a higher CO_2 avoided (95.2% for SEWGS, 90.2% for MEA and 91.0% for MDEA). Decoupling the hydrogen and power islands brings about higher efficiency penalty (12.5%) with 95.3% of CO_2 avoided. Finally, an exergy comparison among all the cases is carried out in order to explain the performance differences, outlining the main advantages of SEWGS in high temperature CO_2 separation with limited energy consumption.

11/02517 Prediction of the overall sieve tray efficiency for a group of hydrocarbons, an artificial neural network approach

Saghatoleslami, N. *et al. Journal of Natural Gas Science and Engineering*, 2011, 3, (1), 319–325.

Mass transfer efficiency is of great importance in the design and analysis of the sieve tray columns, as it relates theoretical to the actual number of stages. However, the empirical models that have so far been presented for the estimation of the tray efficiency are either confined to a particular system or not sufficiently accurate. On the other hand, neural networks are utilized in cases where either mathematical modelling could not be applied or the relationships between the parameters are complex. Therefore, it is the aim of this research to utilize neural network in predicting the overall sieve tray efficiency. To obtain this objective, the overall sieve tray efficiency for eight different compositions (i.e. ethanol/water, acetone/water, methanol/water, acetic-acid/water, toluene/water, methyl-isobutyl-ketone (i.e. MIBK)/water, aniline/nitrobenzene and cyclo-hexane/n-heptane) as a single hydrocarbon system has been computed, using artificial neural network. To assess the performance of the technique, the predicted values of the neural networks have been compared with the experimental data and a correlation proposed elsewhere. The findings of this research reveal that there exist a mean absolute error of 1.21% which is negligible compared to the earlier correlation with absolute error of 18.22%. Therefore, the results of this work demonstrate that multi-layer perceptron neural network could provide a good practice of predicting the overall sieve tray efficiency and with a good degree of accuracy.

Transport, storage

11/02518 Experimental study of filtration system performance of natural gas in urban transmission and distribution network: a case study on the city of Kerman, Iran

Azadi, M. *et al. Fuel*, 2011, 90, (3), 1166–1171.

Suspended particles are well known to cause serious problems in natural gas pipelines and related equipment. In this study, suspended particles in the natural gas transmission and distribution network of the city of Kerman, Iran were investigated. Particle concentration and size distribution were measured, under isokinetic condition, in different locations of the natural gas pipeline network. Additional particle characterization was carried out through SEM/EDX and XRD analysis. The filtration performance was found to be rather inefficient according to the particle concentration in the natural gas flow, although it decreased along the pipeline to the end of the network. Larger particles were more likely to exist at the network entrance with respect to the network pipeline exit. The results of particle characterization confirmed the presence of corrosion products in the suspended particles.

11/02519 Gas market distorting effects of imbalanced gas balancing rules: inefficient regulation of pipeline flexibility

Keyaerts, N. *et al. Energy Policy*, 2011, 39, (2), 865–876.

This paper analyses the value and cost of line-pack flexibility in liberalized gas markets through examination of the techno-economic characteristics of gas transport pipelines and the trade-offs between different ways to use the infrastructure: transport and flexibility. Line-pack flexibility is becoming increasingly important as a tool to balance gas supply and demand over different periods. In the European liberalized market context, a monopolist unbundled network operator offers regulated transport services and flexibility (balancing) services according to the network code and balancing rules. Therefore, gas policy makers should understand the role and consequences of line-pack regulation. The analysis shows that the line-pack flexibility service has an important economic value for the shippers and the TSO. Furthermore, the analysis identifies distorting effects in the gas market due to inadequate regulation of line-pack flexibility: by disregarding the sunk costs of flexibility in the balancing rules, the overall efficiency of the gas system is decreased. Finally, the analysis demonstrates that the actual costs of line-pack flexibility are related to the peak cumulative imbalance throughout the balancing period. Any price for pipeline flexibility should, therefore, be based on the related trade-off between the right to use the line-pack flexibility and the provision of transport services.

11/02520 Molecular dynamics study on the structure I clathrate-hydrate of methane + ethane mixture

Erfan-Niya, H. *et al. Energy Conversion and Management*, 2011, 52, (1), 523–531.

Molecular dynamics (MD) simulations are used to study the structure I stability of methane + ethane clathrate-hydrates at temperatures 273, 275 and 277 K. NVT- and NPT-ensembles are utilized in MD simulation, and each consists of $3 \times 3 \times 3$ replica unit cells containing 46 water molecules which are considered as the host molecules and up to eight methane + ethane molecules considered as the guest molecules. In MD simulations for host–host interactions, the potential model used was a type of simple point charge (SPC) model, and for guest–guest and host–guest interactions the potential used was Lennard–Jones model. In the process of MD simulation, achieving equilibrium of the studied system was recognized by stability in calculated pressure for NVT-ensemble and volume for NPT-ensemble. To understand the characteristic configurations of the structure I hydrate, the radial distribution functions (RDFs) of host–host, host–guest and guest–guest molecules as well as other properties including kinetic energy, potential energy and total energy were calculated. The results show that guest molecules interaction with host molecules cannot decompose the hydrate structure, and these results are consistent with most previous experimental and theoretical investigations that methane + ethane mixtures form structure I hydrates over the entire mixture composition range.

11/02521 Simulation of transients in natural gas pipelines

Dorao, C. A. and Fernandino, M. *Journal of Natural Gas Science and Engineering*, 2011, 3, (1), 349–355.

Cost-effective design and operations of natural gas pipelines require the evaluation of the dynamics of the transmission system, normally modelled as one-dimensional transient compressible fluid. Rapid changes in the flow conditions are present due to disturbances in the demand and operation of the controlling devices. In this work, an alternative approach for simulating the dynamics of natural gas pipelines is presented. The paper describes a time–space least squares spectral method using a C^{11} type *p*–version hierarchical interpolations in space and time. In this formulation, both property space and time are coupled in the least squares minimization procedure. Numerical examples of fast transient cases are discussed.

11/02522 Studying effects of storage types on performance of CNG filling stations

Farzaneh-Gord, M. *et al. Journal of Natural Gas Science and Engineering*, 2011, 3, (1), 334–340.

At a compressed natural gas (CNG) filling station, CNG must be kept in a storage system in order to make the utilization of the station more efficient. There are two systems for storing natural gas, namely buffer and cascade storage systems. In buffer storage, CNG is stored at single high-pressure reservoirs. The cascade storage system is usually divided into three reservoirs, generally termed low-, medium- and high-pressure reservoirs. In the current study, based on the first and second laws of thermodynamics, conversation of mass and real gas assumptions, a theoretical analysis has been developed to study effects of reservation type on performance of CNG filling stations and filling process. Considering the same final natural gas vehicle cylinder (NGV) on-board in-cylinder pressure for both storage systems, the results show that each storage type has advantages over the other. The best configuration should be selected by balancing these advantages.

Economics, business, marketing, policy

11/02523 Design optimization of a polygeneration plant fuelled by natural gas and renewable energy sources

Rubio-Maya, C. *et al. Applied Energy*, 2011, 88, (2), 449–457.

A new and systematic procedure to select and size a polygeneration plant fuelled by natural gas, solar energy and gasified biomass is presented in this paper. The proposed procedure is based on the superstructure definition, containing a long list of possible configurations for a polygeneration plant simultaneously producing electricity, heat, cold and fresh water. Based on that superstructure, a mathematical programming model was developed and applied to a Spanish tourist resort. Three key aspects were optimized in the mathematical programming problem: energy savings, greenhouse gases (GHG) emission reduction and economic feasibility. The results show, firstly, that the simultaneous production of electricity, heat, cold and fresh water is reliable upon the established assumptions. Secondly, that today higher economic profitability is yet achieved with only natural gas-based technologies, although higher energy savings and GHG reduction are obtained through the gradual increase of renewable energy sources.

11/02524 Introducing novel graphical techniques to assess gasification

Ngubevana, L. *et al. Energy Conversion and Management*, 2011, 52, (1), 547–563.

Due to its complexity, coal gasification is perhaps one industry's least understood processes. This is despite the fact that this process is critical to countries such as South Africa, as it is responsible for producing a large portion of the country's fuel needs through the Fischer–Tropsch process. Worldwide, this process has also become critical for applications such as IGCC, for the production of electricity. It is because of this importance that it is necessary to better understand this process. Another motivating factor is that gasifiers are very expensive and are big energy consumers as well as being large carbon dioxide producers. Much experimental work has been done in the area of gasification, but this can be very expensive and is time consuming. It is with this in mind, that the authors have developed a quick, relatively simple and yet very powerful graphical tool to assess and better understand gasification and to use this tool to look for opportunities to improve efficiencies of process and to reduce carbon dioxide emissions. The approach used here is to make a few reasonable assumptions to set up mass balances; the energy balance and reaction equilibria around a coal gasifier. This paper deals with how these balances can be set up; it also looks at what effect the feed composition and choice of reaction conditions (temperature and pressure), may have on the possible gasifier product. The result of this approach shows that the authors can work in a stoichiometric subspace defined by the energy and mass balance. Furthermore it can be shown that gasification is energy and not work limited which has implications for the design and operation of these units.

11/02525 Investigation on heat transfer evaluation for a more efficient two-zone combustion model in the case of natural gas SI engines

Lounici, M. S. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 319–328.

Two-zone model is one of the most interesting engine simulation tools, especially for SI engines. However, the pertinence of the simulation depends on the accuracy of the heat transfer model. In fact, an important part of the fuel energy is transformed to heat loss from the chamber walls. Also, knock appearance is closely related to heat exchange. However, in the previous studies using two-zone models, many choices are made for heat transfer evaluation and no choice influence study has been carried out, in the literature. The current study aims to investigate the effect of the choice of both the heat transfer correlation and burned zone heat transfer area calculation method and provide an optimized choice for a more efficient two-zone thermodynamic model, in the case of natural gas SI engines. For this purpose, a computer simulation is developed. Experimental measurements are carried out for comparison and validation. The effect of correlation choice has been first studied. The most known correlations have been tested and compared. The experimental pressure results, supported for more general and reliable conclusions, by a literature survey of many other studies, based on measured heat transfer rates for several SI engines, are used for correlation selection. It is found that Hohenberg's correlation is the best choice. However, the influence of the burned zone heat transfer area calculation method is negligible.

11/02526 Market integration and price transmission in the U.S. natural gas market: from the wellhead to end use markets

Mohammadi, H. *Energy Economics*, 2011, 33, (2), 227–235.

Examination of the upstream–downstream pricing behaviour in the US natural gas industry reveals that: (a) natural gas markets are integrated but subject to regime shifts and asymmetric adjustments, suggesting market imperfections. (b) Demand- and supply-side shocks play important roles in determining short-run price movements as evidenced by tests of causality and impulse response functions. (c) The response of end use prices to deviations from equilibrium with wellhead prices vary. Electrical, industrial and city gate prices adjust fast while commercial and residential prices adjust slowly, consistent with the role of administered pricing in later markets.

(d) Long-run variations in end use prices are primarily due to their own shocks, while long-run variations in wellhead prices are due to innovations in residential and electrical prices. These findings point to the importance of demand shocks as the primary determinant of natural gas prices in the long-run.

11/02527 Modeling the European natural gas market during the 2009 Russian–Ukrainian gas conflict: ex-post simulation and analysis

Lochner, S. *Journal of Natural Gas Science and Engineering*, 2011, 3, (1), 341–348.

Analysing short-term security of supply or the degree of physical market integration in the European gas market requires models with high spatial and temporal granularity which allow to do so in a comprehensive manner taking interdependencies in the supply infrastructure into account. This paper presents an infrastructure and dispatch model of the European gas market which enables such analyses. The *ex post* application of the model to the January 2009 Russia–Ukraine crisis yields that the market's reaction to the crisis was close to the optimal least-cost response implying a very efficient handling of the transit disruption by the gas sector. While large diversions of gas flows from the west to the east were possible, a high dependence on one import route, limited infrastructure flexibility and storage volumes in eastern Europe hampered security of supply in this region. Generally, the results confirm the importance of gas stocks in mitigating risks from supply disruptions as additional storage withdrawals compensated more than two thirds of supply shortfalls during the crisis. Further simulations also demonstrate that increasing flexibility of the transport system (reverse flow capabilities) enhances security of supply for further consumers in eastern Europe, but not for all of them.

11/02528 Regulation and development of the Argentinean gas market

Ponzo, R. *et al. Energy Policy*, 2011, 39, (3), 1070–1079.

Gas markets are becoming increasingly important around the world and the long-term evolution of these markets is of strategic importance for many countries. This makes it essential to understand how regulation and intervention in these markets affects the long-term prospect for the secure supply of gas. The authors use Argentina as a case to illustrate some of the issues and consequences of gas regulation. Argentina is a country that has had a significant increase in the use of gas over the years, and where a potential gas deficit looms large in the present and the future. Based on a simulation model developed to understand the supply of gas in Argentina, the authors discuss how regulation will influence the long-term supply of gas in both Argentina and surrounding countries. Using the model, the authors develop a series of scenarios to highlight the consequences of different current and possible future interventions in the market by the regulator. Finally, they discuss short-term regulatory options to reduce the impact of a gas deficit, and the possibility of securing the long-term supply of gas in Argentina.

11/02529 Risk factors in oil and gas industry returns: international evidence

Ramos, S. B. and Veiga, H. *Energy Economics*, 2011, 33, (3), 525–542.

The recent boom in oil prices has attracted many investors to oil companies in search of both returns and diversification benefits. This analysis of the risk factors of investing in the oil and gas industry in 34 countries finds evidence that oil price is a globally priced factor for the oil industry. The oil and gas sector in developed countries responds more strongly to oil price changes than in emerging markets. Oil and gas industry returns also respond asymmetrically to changes in oil prices; oil price rises have a greater impact than oil price drops. There is no parallel to the asymmetry of oil price changes in other industries related to commodities. If there is any asymmetry, it is in the opposite direction from oil. Negative commodity price changes have a greater impact than positive ones. The results seem to indicate that the oil and gas industry is distinguished by a pass-through effect.

11/02530 The co-evolution of alternative fuel infrastructure and vehicles: a study of the experience of Argentina with compressed natural gas

Collantes, G. and Melaina, M. W. *Energy Policy*, 2011, 39, (2), 664–675.

This study examines the experience of Argentina with compressed natural gas. The authors conducted interviews with a wide range of stakeholders and analysed econometrically data collected in Argentina to investigate the factors, economic, political, and others that determined the high rate of adoption of this fuel. A central objective of this research was to identify lessons that could be useful to developed countries in their efforts to deploy alternative fuel vehicles. Fuel price regulation was found to be a significant determinant of the adoption of compressed natural gas, while, contrary to expectations, government financing of refuelling infrastructure was minimal.

Derived gaseous fuels

11/02531 A solid oxide membrane electrolyzer for production of hydrogen and syn-gas from steam and hydrocarbon waste in a single step

Pati, S. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 152–159.

This paper describes a novel solid oxide membrane (SOM) electrolyser that can utilize the energy value in any hydrocarbon waste or reductant to lower the energy requirement for hydrogen production from steam. The SOM electrolyser consists of a one-end closed oxygen-ion-conducting yttria stabilized zirconia (YSZ) tube with Ni–YSZ cathode coated on the outside and liquid metal anode inside the tube. The SOM electrolyser is operated by feeding steam on the cathodic side and hydrocarbon reductant in the liquid metal anode. By feeding hydrocarbon waste it is possible to lower the chemical potential of oxygen in the liquid metal such that the SOM electrolyser can spontaneously dissociate steam and generate hydrogen on the cathodic side and oxidize the hydrocarbon waste on the anodic side to produce syngas. The rate of these reactions can be increased by applying a small potential across the electrodes.

11/02532 Biogenic hydrogen and methane production from reed canary grass

Lakaniemi, A.-M. *et al. Biomass and Bioenergy*, 2011, 35, (2), 773–780.

The composition, biodegradability, abundance, availability and cost determine the amenability of carbonaceous substrate for fermentative hydrogen and methane production systems. The aim of the present work was to determine suitability of lignocellulosic material, reed canary grass (RCG) (*Phalaris arundinacea* L.), for hydrogen and methane production at 35 °C by utilizing solid RCG and acid hydrolysed soluble RCG. Synthetic cellulose was used as control substrate. Acid hydrolysis released $61.7\,\mathrm{mg\,g^{-1}}$ (dw) and $115\,\mathrm{mg\,g^{-1}}$ (dw) of reducing sugars from synthetic cellulose and chopped RCG, respectively. More hydrogen was produced from acid hydrolysed RCG than from solid RCG, the highest yield being 1.25 mmol H_2 per *g* (dw) RCG. Methane production from solid RCG resulted in the highest yield of 8.26 mmol CH_4 per *g* (dw) RCG. In summary hydrogen and methane was produced from RCG, and acid hydrolysis was required for hydrogen, but not for methane production.

11/02533 Characteristics of syngas from co-gasification of polyethylene and woodchips

Ahmed, I. I. *et al. Applied Energy*, 2011, 88, (1), 165–174.

Gasification of polyethylene (PE) and woodchips (WC) mixtures have been investigated in a semi-batch reactor, using high temperature steam as the gasifying agent. The reactor temperature was maintained at 900 °C. The ratio of PE–WC was varied from 0% to 100% in 20% intervals. Characteristics of syngas were evaluated based on the yield of syngas, hydrogen, energy, ethylene, total hydrocarbons and apparent thermal efficiency of the process. Results show that properties of syngas evolved during gasification of PE–WC blends cannot be determined from the weighted average syngas properties obtained from separate gasification of WC and PE. Superior results in terms of syngas yield, hydrogen yield, total hydrocarbons yield, energy yield and apparent thermal efficiency from PE–WC blends were obtained as compared to expected weighed average yields from gasification of individual components. Results confirm synergistic interaction between PE and WC during high temperature steam gasification of these mixtures. These results also provide the importance of mixing two or more compounds on the performance of stream gasification of wastes.

11/02534 Gasification of heavy fuel oils: a thermochemical equilibrium approach

Vaezi, M. *et al. Fuel*, 2011, 90, (2), 878–885.

Combustion of heavy fuel oils is a major source of production of particulate emissions and ash, as well as considerable volumes of SO_x and NO_x. Gasification is a technologically advanced and environmentally friendly process of disposing heavy fuel oils by converting them into clean combustible gas products. Thermochemical equilibrium modelling is the basis of an original numerical method implemented in this study to predict the performance of a heavy fuel oil gasifier. The model combines both the chemical and thermodynamic equilibriums of the global gasification reaction in order to predict the final syngas species distribution. Having obtained the composition of the produced syngas, various characteristics of the gasification process can be determined; they include the H_2:CO ratio, process temperature, and heating value of the produced syngas, as well as the cold gas efficiency and carbon conversion efficiency of the process. The influence of the equivalence ratio, oxygen enrichment (the amount of oxygen available in the gasification agent), and pressure on the gasification characteristics is analysed. The results of simulations are compared with reported experimental measurements through which the numerical model is validated. The detailed investigation performed in the course of this study reveals that the heavy oil gasification is a feasible process that can be utilized to generate a syngas for various industrial applications.

11/02535 Interaction of coal-derived synthesis gas impurities with solid oxide fuel cell metallic components

Marina, O. A. *et al. Journal of Power Sources*, 2011, 196, (2), 636–643.
Oxidation-resistant alloys find use as interconnect materials, heat exchangers, and gas supply tubing in solid oxide fuel cell (SOFC) systems, especially when operated at temperatures below ~800 °C. If fuelled with synthesis gas derived from coal or biomass, such metallic components could be exposed to impurities contained in those fuel sources. In this study, coupons of ferritic stainless steels Crofer 22 APU and SS 441, austenitic nickel–chromium superalloy Inconel 600, and an alumina-forming high nickel alloy alumel were exposed to synthesis gas containing $\leq$2 ppm phosphorus, arsenic and antimony, and reaction products were tested. Crofer 22 APU coupons coated with a $(Mn,Co)_3O_4$ protective layer were also evaluated. Phosphorus was found to be the most reactive. On Crofer 22 APU, the $(Mn,Cr)_3O_4$ passivation layer reacted to form an Mn–P–O product, predicted to be manganese phosphate from thermochemical calculations, and Cr_2O_3. On SS 441, reaction of phosphorus with $(Mn,Cr)_3O_4$ led to the formation of manganese phosphate as well as an Fe–P product, predicted from thermochemical calculations to be Fe_3P. Minimal interactions with antimony or arsenic in synthesis gas were limited to Fe–Sb and Fe–As solid solution formation. Though not intended for use on the anode side, a $(Mn,Co)_3O_4$ spinel coating on Crofer 22 APU reacted with phosphorus in synthesis gas to produce products consistent with $Mn_3(PO_4)_2$ and Co_2P. A thin Cr_2O_3 passivation layer on Inconel 600 did not prevent the formation of nickel phosphides and arsenides and of iron phosphides and arsenides, though no reaction with Cr_2O_3 was apparent. On alumel, an Al_2O_3 passivation layer rich in Ni did not prevent the formation of nickel phosphides, arsenides, and antimonides, though no reaction with Al_2O_3 occurred. This work shows that unprotected metallic components of an SOFC stack and system can provide a sink for P, As and Sb impurities that may be present in fuel gases, and thus complicate experimental studies of impurity interactions with the anode.

11/02536 Modeling and comparison of different syngas cooling types for entrained-flow gasifier

Ni, J. *et al. Chemical Engineering Science*, 2011, 66, (3), 448–459.
A three-dimensional numerical model has been developed for studying the multiphase flow and heat transfer process in the syngas cooler. The realizable k–ε turbulent model and discrete random walk (DRW) model were adopted to simulate the gas phase and particle phase flow fields, respectively. The discrete ordinate model (DOM) was applied to solve the radiative heat transfer equation, and the gas radiative properties were calculated by weight-sum-of-grey-gases model (WSGGM). The ash particle radiative properties were also considered in the radiative heat transfer calculation. The convection heat-transfer between the gas phase and discrete phase is also considered. The flow field and temperature distribution results are in good agreement with the experimental data. First, the results indicate that the RSC should be the better choice for integrated gasification combined cycle (IGCC) power plant. For cooling-syngas quenching cooler, the outlet region has higher risk of fouling and slagging because the outlet gas and particle temperature are about 940 °C, and exceed the criteria temperature 760 °C (suggested in the literature). Secondly, when the inlet velocity and flow rate of the quenching gas are fixed, the more the quenching gas inlets are, the better the flow field and temperature field are. A recirculation region with the diameter about 1.5–2.0 m is formed in the centre of the cooler under the quenching gas profile, and the intensity of the reflux flow increases with the number of quenching gas inlets. The particles are rapidly quenched when the particle flow through the quenching gas profile. Furthermore, the temperature of the quenching gas, and the temperature of the water in the tubes of membrane wall also have important effect on the temperature field in the radiant syngas cooler.

11/02537 Potential of synthesis gas production from rubber wood chip gasification in a bubbling fluidised bed gasifier

Kaewluan, S. and Pipatmanomai, S. *Energy Conversion and Management*, 2011, 52, (1), 75–84.
Experiments of rubber wood chip gasification were carried out in a 100-kW$_{th}$ bubbling fluidized bed gasifier to investigate the effect of air-to-fuel ratio (represented as equivalence ratio, ER) on the yield and properties of synthesis gas. For all experiments, the flow rate of ambient air was fixed, while the feed rate of rubber wood chip was adjusted to vary ER in the range of 0.32–0.43. Increasing ER continuously raised the bed temperature, which resulted in higher synthesis gas yield and lower yield of ash and tar. However, higher ER generally gave synthesis gas of lower heating value, partly due to the dilution of N_2. Considering the energy efficiency of the process, the optimum operation was achieved at ER = 0.38, which yielded 2.33 Nm^3 of synthesis gas per kg of dry biomass at the heating value of 4.94 MJ/Nm^3. The calculated carbon conversion efficiency and gasification efficiency were 97.3% and 80.2%, respectively. The mass and energy balance of the gasification process showed that the mass and energy distribution was significantly affected by ER and that the energy losses accounted for approximately 25% of the total output energy. The economical assessment of synthesis gas utilization for heat and electricity production based on a 1-MW$_{th}$ bubbling fluidized bed gasifier and the operational data resulting from the rubber wood chip gasification experiments in this study clearly demonstrated the attractiveness of replacing heavy fuel oil and natural gas by the synthesis gas for heat applications in terms of 70% and 50% annual saving of fuel cost, respectively. However, the case of electricity production does not seem a preferable option due to its current technical and non-technical barriers.

LNG

11/02538 LNG as a potential alternative fuel – safety and security of storage facilities

Bernatik, A. *et al. Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 19–24.
The aim of this article is to summarize the safety and security aspects of storing of liquefied natural gas (LNG) as a potential alternative fuel. The contribution deals with possible scenarios of accidents associated with LNG storage facilities and with a methodology for the assessment of vulnerability of such facilities. The protection of LNG storage facilities as element of critical infrastructure should also be a matter of interest to the state. The study presents the results of determination of hazardous zones around LNG facilities in the event of various sorts of release. For calculations, the programs ALOHA, EFFECTS and TerEx were used and results obtained were compared. Scenarios modelled within this study represent a possible approach to the preliminary assessment of risk that should be verified by more detailed modelling (computational fluid dynamics). These scenarios can also be used for a quick estimation of areas endangered by an incident or accident. The results of modelling of the hazardous zones contribute to a reduction in risk of major accidents associated with these potential alternative energy sources.

11/02539 LNG cold energy use in agro-food industry: a case study in Sicily

Messineo, A. and Panno, G. *Journal of Natural Gas Science and Engineering*, 2011, 3, (1), 356–363.
It is known how the complete gasification of liquefied natural gas (LNG) can return about 230 kWh/t of energy. Nevertheless out of 51 gasification plants in the world, only 31 of them are equipped with systems for the partial recovery of the available energy. At the moment, most of these plants mainly produce electric energy; however the employment of the cold energy results very interesting, in fact, it can be recovered for agro-food transformation and conservation as well as for some loops in the cold chain. Cold energy at low temperatures requires high amounts of mechanical energy and it unavoidably increases as the required temperature diminishes. Cold energy recovery from LNG gasification would allow considerable energy and economic savings to these applications, as well as environmental benefits due to the reduction of climate-changing gas emissions. The task of this work is to assess the possibility to create around a gasification plant an industrial site for firms working on the transformation and conservation of agro-food products locally grown. The cold energy recovered from gasification would be distributed to those firms through an opportune liquid carbon dioxide network distribution capable of supplying 'the cold' to the different facilities. A LNG gasification plant in a highly agricultural zone in Sicily would increase the worth of the agro-food production, lower transformation and conservation costs when compared to the traditional systems and bring economic and environmental benefits to the interested areas.

11/02540 Natural gas prices, LNG transport costs, and the dynamics of LNG imports

Maxwell, D. *et al. Energy Economics*, 2011, 33, (2), 217–226.
According to the US Energy Information Administration, LNG is projected to become a much larger share of US natural gas consumption, rising from current levels of around 2.5% of total natural gas consumption to 12.4% by 2030. Because natural gas and LNG are substitutes, natural gas prices are expected to be an important determinant of LNG imports. Furthermore, an increasing share of LNG is traded under short-term contracts with spot shipments being diverted to markets offering the highest returns (netbacks). Relative natural gas prices as well as LNG transportation costs are important

determinants of LNG netbacks. This paper examines the empirical relationship between US LNG imports, the Henry hub price of natural gas relative to British and Asian gas prices, and a proxy for LNG transportation costs using monthly data from 1997 to 2007. Granger causality tests, error variance decomposition, and impulse response analyses using a VAR model are employed to establish Granger-causality as well as the dynamics of natural gas prices and LNG transportation innovations on LNG imports.

11/02541 The role of real gas Brayton cycles for the use of liquid natural gas physical exergy

Angelino, G. and Invernizzi, C. M. *Applied Thermal Engineering*, 2011, 31, (5), 827–833.

When using the cooling capacity of LNG several thermodynamic schemes are proposable employing conventional and non-conventional conversion cycles. All conventional systems make use of organic working fluids such as methane or propane in series of Rankine cycles used in a cascading mode. A simpler system is available, using a single cycle and a single fluid in a Brayton cycle. However ordinary Brayton cycles exhibit a modest efficiency. Resorting to Brayton cycles with strong real gas effects (which is possible selecting the base parameters of pressure and temperature in the vicinity of the critical point) improves considerable cycle performance. Since the level of cold in a LNG flow is thermodynamically predetermined, working fluids must be selected with a critical point which fit the LNG thermal capacity, i.e. some 5–15 C higher than the usual LNG temperature which is around −160 °C. Nitrogen was found as the best fluid to exploit real gas effects with efficiencies above 63% while perfect gas cycles give efficiencies around 56%. However, in real gas cycles the cooling capacity of LNG is only partially exploited: a better exploitation is obtained from perfect gas cycles or for more complex cascading Rankine cycle. Selecting working fluids with a higher critical temperature than nitrogen, as for example argon, the efficiency decreases to 58% respect to 63% for nitrogen, but the utilization of the cold of LNG improves from 0.30 MW/(kg/s) to 0.75 MW/(kg/s). Obviously as heat rejection temperature increases a larger fraction of cold in the LNG flow can be utilized. Combined cycles making use of a gas turbine offer also a good performance. The merits of real gas effect Brayton cycles also in this case remains evident. Finally, it is theoretically possible to use real gas effect Brayton cycles at low temperatures, which are typical of waste heat (say 100–150 °C: in this case cycle efficiency remain good, but power obtainable from a unit flow of LNG is modest.

11/02542 Ukraine looks for gas

Anon., *Oil and Energy Trends*, 2011, 36, (2), 7–8.

Ukraine is keen to reduce its reliance on imports of natural gas from Russia. With a view to potential future supplies from countries such as Azerbaijan, Egypt and Qatar, plans have been announced for an LNG import terminal on the Black Sea.

Hydrogen generation and storage

11/02543 Bio-hydrogen production based on catalytic reforming of volatiles generated by cellulose pyrolysis: an integrated process for ZnO reduction and zinc nanostructures fabrication

Maciel, A. V. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1121–1129.

The paper presents a process of cellulose thermal degradation with bio-hydrogen generation and zinc nanostructures synthesis. Production of zinc nanowires and zinc nanoflowers was performed by a novel processes based on cellulose pyrolysis, volatiles reforming and direct reduction of ZnO. The bio-hydrogen generated *in situ* promoted the ZnO reduction with Zn nanostructures formation by vapour–solid (VS) route. The cellulose and cellulose/ZnO samples were characterized by thermal analyses (TG/DTG/DTA) and the gases evolved were analysed by FTIR spectroscopy (TG/FTIR). The hydrogen was detected by TPR (temperature programmed reaction) tests. The results showed that in the presence of ZnO the cellulose thermal degradation produced larger amounts of H_2 when compared to pure cellulose. The process was also carried out in a tubular furnace with N_2 atmosphere, at temperatures up to 900 °C, and different heating rates. The nanostructures growth was catalyst-free, without pressure reduction, at temperatures lower than those required in the carbothermal reduction of ZnO with fossil carbon. The nanostructures were investigated by X-ray diffraction (XRD), scanning electron microscopy, energy-dispersive X-ray spectroscopy and transmission electron microscopy. The optical properties were investigated by photoluminescence. One mechanism was presented in an attempt to explain the synthesis of zinc nanostructures that are crystalline, were obtained without significant re-oxidation and whose morphologies are dependent on the heating rates of the process. This route presents a potential use as an industrial process taking into account the simple operational conditions, the low costs of cellulose and the importance of bio-hydrogen and nanostructured zinc.

11/02544 Chemical hydrogen storage using polynuclear borane anion salts

Safronov, A. V. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 234–239.

The polynuclear borane anions *nido*-$B_{11}H_{14}^{-}$, *closo*-$B_{10}H_{10}^{2-}$ and *closo*-$B_{12}H_{12}^{2-}$ undergo heterogeneous transition metal-catalysed hydrolysis to generate hydrogen. The rate of hydrolysis is dependent on the concentration of polynuclear borane anions and surface area of the metallic catalyst. The aqueous solutions of polynuclear borane anions, especially the *closo*-$B_{10}H_{10}^{2-}$ and *closo*-$B_{12}H_{12}^{2-}$ dianions, are very stable for an extended period of time (years) in the absence of catalyst and spontaneously generate hydrogen in the presence of a rhodium metal catalyst. These polynuclear borane anions have a high potential for use in portable hydrogen storage systems without requiring high pH aqueous media for storage as in the case of $NaBH_4$.

11/02545 Comparative study of biological hydrogen production by pure strains and consortia of facultative and strict anaerobic bacteria

Hiligsmann, S. *et al. Bioresource Technology*, 2011, 102, (4), 3810–3818.

In this paper, a simple and rapid method was developed in order to assess in comparative tests the production of binary biogas mixtures containing CO_2 and another gaseous compound such as hydrogen or methane. This method was validated and experimented for the characterization of the biochemical hydrogen potential of different pure strains and mixed cultures of hydrogen-producing bacteria (HPB) growing on glucose. The experimental results compared the hydrogen production yield of 19 different pure strains and sludges: facultative and strict anaerobic HPB strains along with anaerobic digester sludges thermally pre-treated or not. Significant yields variations were recorded even between different strains of the same species by about 20% for three *Clostridium butyricum* strains. The pure *C. butyricum* and *pasteurianum* strains achieved the highest yields, up to 1.36 mol H_2/mol glucose compared to the yields achieved by the sludges and the tested *Escherichia* and *Citrobacter* strains.

11/02546 Development of efficient photoreactors for solar hydrogen production

Huang, C. *et al. Solar Energy*, 2011, 85, (1), 19–27.

The rate of hydrogen evolution from a photocatalytic process depends not only on the activity of a photocatalyst, but also on photoreactor design. Ideally, a photoreactor should be able to absorb the incident light, promoting photocatalytic reactions in an effective manner with minimal photonic losses. There are numerous technical challenges and cost related issues when designing a large-scale photoreactor for hydrogen production. Active stirring of the photocatalyst slurry within a photoreactor is not practical in large-scale applications due to cost related issues. Rather, the design should allow facile self-mixing of the flow field within the photoreactor. In this paper two types of photocatalytic reactor configurations are studied: a batch type design and another involving passive self-mixing of the photolyte. Results show that energy loss from a properly designed photoreactor is mainly due to reflection losses from the photoreactor window. The authors describe the interplay between the reaction and the photoreactor design parameters as well as effects on the rate of hydrogen evolution. They found that a passive self-mixing of the photolyte is possible. Furthermore, the use of certain engineering polymer films as photoreactor window materials has the potential for substantial cost savings in large-scale applications, with minimal reduction of photon energy utilization efficiency. Eight window materials were tested and the results indicate that Aclar polymer film used as the photoreactor window provides a substantial cost saving over other engineering polymers, especially with respect to fused silica glass at modest hydrogen evolution rates.

11/02547 Effect of catalyst activity in SMR-SERP for hydrogen production: commercial vs. large-pore catalyst

Oliveira, E. L. G. *et al. Chemical Engineering Science*, 2011, 66, (3), 342–354.

In this work, the authors have evaluated the performance of an SMR-SERP unit (steam methane reforming sorption enhanced reaction process), using two different Ni/Al_2O_3 catalysts: commercial 'Octolyst 2001' from Degussa and a large-pore catalyst (catalyst A). The selective CO_2 sorbent was a potassium modified hydrotalcites. Several experiments were performed under different operating conditions to validate a mathematical model. Experimental results show that the Degussa catalyst is more active and more selective to CO_2 producing hydrogen with higher purity and less CO than the large-pore catalyst. Cyclic SMR-SERP experiments were also performed. The cycles comprise four different steps: reaction, depressurization, reactive regeneration and pressurization. In the cyclic experiments, conversion was 43%

higher than in an SMR reactor, while H_2 purity was 75%, which is 25% higher than in normal SMR operation. Results indicate that more active catalysts also promote a better reactive regeneration optimizing the use of part of the product (H_2). The proposed mathematical model was validated in a wide range of operating conditions and in a cyclic experiment. The model was able to describe the SMR-SERP experiments without any fitting parameters.

11/02548 Electrocatalytic activity of simple and modified Fe–P electrodeposits for hydrogen evolution from alkaline media

Sequeira, C.A.C. *et al. Energy*, 2011, 36, (2), 847–853.

Electrodeposition of Fe–P, Fe–P–Pt and Fe–P–Ce into copper substrates is carried out under galvanostatic conditions. The influence of the current density on the composition of the deposits and the current efficiencies for the electrodeposition processes are determined. Preliminary data indicate that addition of formic acid to the electroplating bath improves the current efficiency for electrodeposition. Electrocatalytic activities of the heat-treated plated materials are investigated by dc polarization and ac impedance techniques for the hydrogen evolution reaction (HER) in 1 M NaOH solution at 298 K. Steady-state polarization curves and electrochemical impedance spectroscopy data show that improved catalytic activities for the HER are due to an increase in the effective surface area, a change in surface features upon heat treatment, the partial contribution of the Pt component, and the electrocatalytic synergism with Fe imposed by the Ce co-deposit. Cathodic potentiostatic measurements for medium time operation indicate that the electroplated materials are stable even in moderately aggressive alkaline solutions.

11/02549 Enhanced heat exchanger design for hydrogen storage using high-pressure metal hydride: part 1. Design methodology and computational results

Visaria, M. *et al. International Journal of Heat and Mass Transfer*, 2011, 54, (1–3), 413–423.

This study explores the use of a high-pressure metal hydride (HPMH), $Ti_{1.1}CrMn$, to store hydrogen at high pressures (up to 310 bar) and temperatures below 60 °C, conditions that are suitable for automobile fuel cells. However, the exothermic reaction of hydrogen with this material releases large amounts of heat, and the reaction rate depends on the metal hydride temperature, decreasing significantly if the heat is not removed quickly. Therefore, a powerful heat exchanger constitutes the most crucial component of a HPMH hydrogen storage system. For automobiles, this heat exchanger must enable fuelling 5 kg of hydrogen in less than 5 min. This is a formidable challenge considering the enormous amount of heat that must be released and the stringent limits on the heat exchanger's weight and volume, let alone a host of manufacturing requirements. Unlike conventional heat exchangers that are designed to exchange heat between two fluids, this heat exchanger is quite unique in that it must dissipate heat between a reacting powder and a coolant. In this first of a two-part study, a systematic heat exchanger design methodology is presented, starting with a one-dimensional criterion and progressing through a series of engineering decisions supported by computations of fill time. A final design is arrived at that meets the 5-min fill time requirement corresponding to minimum heat exchanger mass, supported by a two-dimensional computational model of the heat exchanger's thermal and kinetic response.

11/02550 Enhanced heat exchanger design for hydrogen storage using high-pressure metal hydride: part 2. Experimental results

Visaria, M. *et al. International Journal of Heat and Mass Transfer*, 2011, 54, (1–3), 424–432.

Hydrogen storage systems utilizing high-pressure metal hydrides (HPMHs) require a highly effective heat exchanger to remove the large amounts of heat released once the hydrogen is charged into the system. Aside from removing the heat, the heat exchanger must be able to accomplish this task in an acceptably short period of time. A near-term target for this 'fill-time' is less than 5 min. In this two-part study, a new class of heat exchangers is proposed for automobile hydrogen storage systems. Part 1 of this paper discussed the design methodology and a two-dimensional computational model that was constructed to explore the thermal and kinetic behaviour of the metal hydride. This paper discusses the experimental setup and testing of a prototype heat exchanger using $Ti_{1.1}CrMn$ as HPMH storage material. Tests were performed to examine the influence of pressurization profile, coolant flow rate and coolant temperature on metal hydride temperature and reaction rate. The experimental data are compared with predictions of the two-dimensional model to validate the model, calculate reaction progress and determine fill time. The prototype heat exchanger successfully achieved a fill time of 4 min 40 s with a combination of fast pressurization and low coolant temperature. A parameter termed non-dimensional conductance (NDC) is shown to be an effective tool in designing HPMH heat exchangers and estimating fill times achievable with a particular design.

11/02551 Hydrogen production by aqueous phase catalytic reforming of glycerine

Özgür, D. Ö. and Uysal, B. Z. *Biomass and Bioenergy*, 2011, 35, (2), 822–826.

Hydrogen is believed to be the one of the main energy carriers in the near future. In this research glycerine, which is produced in large quantities as a by-product of biodiesel process, was converted to hydrogen aiming to contribute to clean energy initiative. Conversion of glycerol to hydrogen was achieved via aqueous-phase reforming (APR) with Pt/Al_2O_3 catalyst. The experiments were carried out in an autoclave reactor and a continuous fixed-bed reactor. The effects of reaction temperature (160–280 °C), feed flow rate (0.05–0.5 mL/dak) and feed concentration (5–85 wt-% glycerine) on product distribution were investigated. Optimum temperature for hydrogen production with APR was determined as 230 °C. Maximum gas production rate was found at the feed flow rates around 0.1 mL/min. It was also found that hydrogen concentration in the gas product increased with decreasing glycerol concentration in the feed.

11/02552 Hydrogen production by sorption enhanced steam reforming of propane: a thermodynamic investigation

Wang, X. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 466–472.

Thermodynamic features of hydrogen production by sorption enhanced steam reforming (SESR) of propane have been studied with the method of Gibbs free energy minimization and contrasted with propane steam reforming (SR). The effects of pressure (1–5 atm), temperature (700–1100 K) and water to propane ratio (WPR, 1–18) on equilibrium compositions and carbon formation are investigated. The results suggest that atmospheric pressure and a WPR of 12 are suitable for hydrogen production from both SR and SESR of propane. High WPR is favourable to inhibit carbon formation. The minimum WPR required to eliminate carbon production is 6 in both SR and SESR. The most favourable temperature for propane SR is approximately 950 K at which 1 mol of propane has the capacity to produce 9.1 mol of hydrogen. The optimum temperature for SESR is approximately 825 K, which is over 100 K lower than that for SR. Other key benefits include enhanced hydrogen production of nearly 10 mol (stoichiometric value) of hydrogen per mole of propane at 700 K, increased hydrogen purity (99% compared with 74% in SR) and no CO_2 or CO production with the only impurity being CH_4, all indicating a great potential of SESR of propane for hydrogen production.

11/02553 Hydrogen storage properties of lithium silicon alloy synthesized by mechanical alloying

Doi, K. *et al. Journal of Power Sources*, 2011, 196, (1), 504–507.

A lithium silicon alloy was synthesized by mechanical alloying method. Hydrogen storage properties of this Li–Si–H system were studied. During hydrogenation of the lithium silicon alloy, lithium atom was extracted from the alloy and lithium hydride was generated. Equilibrium hydrogen pressures for desorption and absorption reactions were measured in a temperature range from 400 to 500 °C to investigate the thermodynamic characteristics of the system, which can reversibly store 5.4 mass% hydrogen with smaller reaction enthalpy than simple metal lithium. Lithium-absorbing alloys, which have been widely studied as a negative electrode material for Li ion rechargeable batteries, can be used as hydrogen storage materials with high hydrogen capacity.

11/02554 Integrated membrane system for pure hydrogen production: a Pd–Ag membrane reactor and a PEMFC

Brunetti, A. *et al. Fuel Processing Technology*, 2011, 92, (1), 166–174.

In this work, an integrated system consisting of single stage hydrogen production and a commercial PEMFC was investigated experimentally. The CO-free hydrogen fed to the PEMFC was produced in a Pd–Ag membrane reactor (MR), upgrading a syngas stream with a composition similar to that coming out of a reformer (CO 45%; H_2 50%; CO_2 4%; N_2 balance, on dry basis). The performance of the MR was evaluated in terms of CO conversion and H_2 recovery as a function of the feed pressure (up to 600 kPa) and space velocity; no sweep gas was used for promoting the H_2 permeation, since this role was assigned exclusively to the feed pressure. Special attention was paid to the analysis of the integrated system, focusing on the influence of the Pd–Ag MR operating conditions on the electrical performance of the PEMFC. The PEMFC internal crossover was also considered to have an effect on the electrical performance and this was taken into account estimating the PEMFC actual efficiency. Furthermore, the chemical efficiency of the integrated membrane plant was evaluated, considering the H_2 converted into electricity with respect to the total amount of H_2

contained in the feed mixture. An interesting performance was shown by the integrated system since the PEMFC performance was close to the power nominal value.

11/02555 Mono-dispersed transition metal nanoparticles on boron-substituted carbon support and applications in hydrogen storage

Jeong, Y. and Chung, T. C. M. *Carbon*, 2011, 49, (1), 140–146.

To prepare mono-dispersed transition metal nanoparticles on activated carbon supports is a long scientific challenge, due to low graphene surface energy. Few polar functional groups in activated carbon are only located on the plane edges, which are intrinsically difficult to prevent metal clustering, especially at elevated temperatures. This paper discusses a versatile method in preparing stable and uniform transition metal (Pt, Pd, Ti, etc.) nanoparticles (diameter approximately 2 nm), using a newly developed boron-substituted carbon (BC_x) support, containing uniform boron atoms distributed in the graphene layer structure, which provides a strong specific interaction; this interaction is formed by d-electrons back-donation from transition metals to the empty p-orbital in substituted boron atoms. The BC_x support shows good adsorption capacity of metal precursors in solutions, and securing the forming metal nanoparticles during thermal reduction at a high temperature ($>500\,^{\circ}C$). The resulting Pt/BC_{12} – with only 0.7 wt% Pt content – exhibits very high surface activities. At ambient temperature, it offers an impressive hydrogen adsorption capacity at ~0.5 wt% per 500 m^2/g surface area, which is more than five times higher than the corresponding activated carbon material with the same surface area.

11/02556 Natural gas fuelled chemical looping reforming with carbon dioxide capture technology for hydrogen generation: thermodynamic investigation

Wang, W. *et al. Journal of the Energy Institute*, 2011, 84, (2), 94–101.

Chemical looping reforming with CO_2 capture is a method for pure hydrogen generation with inherent separation of CO_2. This technology involves the use of three interconnected reactors: an air reactor, a fuel reactor and a CO_2 releasing reactor. The oxygen demanded in the fuel reforming is supplied by a solid oxygen carrier, which circulates between the fuel reactor and the air reactor. Fuel and air are never mixed, and pure H_2 and CO_2 can be obtained from the outlet of the fuel reactor and the CO_2 releasing reactor respectively. A thermal analysis of the process using NiO as an oxygen carrier was performed by simulating reactions using the Gibbs energy minimization method. The promising systems were investigated further with respect to temperature, oxygen excess numbers, CaO/CH_4 molar ratio and pressure changes in the fuel reactor as well as possible carbon formation in the fuel reactor. It is found that the process has the potential to achieve high efficiency in addition to CO_2 capture.

11/02557 Performance evaluation and phylogenetic characterization of anaerobic fluidized bed reactors using ground tire and pet as support materials for biohydrogen production

Barros, A. R. *et al. Bioresource Technology*, 2011, 102, (4), 3840–3847.

This study evaluated two different support materials (ground tyre and polyethylene terephthalate, PET) for biohydrogen production in an anaerobic fluidized bed reactor (AFBR) treating synthetic wastewater containing glucose ($4000\,mg\,L^{-1}$). The AFBR, which contained either ground tyre (R1) or PET (R2) as support materials, were inoculated with thermally pretreated anaerobic sludge and operated at a temperature of 30 °C. The AFBR were operated with a range of hydraulic retention times (HRT) between 1 and 8 h. The reactor R1 operating with a HRT of 2 h showed better performance than reactor R2, reaching a maximum hydrogen yield of 2.25 mol $H_2\,mol^{-1}$ glucose with 1.3 mg of biomass (as the total volatile solids) attached to each gram of ground tyre. Subsequent 16S rRNA gene sequencing and phylogenetic analysis of particle samples revealed that reactor R1 favoured the presence of hydrogen-producing bacteria such as *Clostridium*, *Bacillus*, and *Enterobacter*.

11/02558 Photocatalytic acetic acid decomposition leading to the production of hydrocarbons and hydrogen on Fe-modified TiO_2

Mozia, S. *et al. Catalysis Today*, 2011, 161, (1), 189–195.

A photocatalytic generation of useful hydrocarbons and hydrogen from acetic acid under N_2 atmosphere is presented. The photocatalysts were prepared from a crude TiO_2 modified with $Fe(NO_3)_3$ and calcinated at the temperatures of 400–600 °C in argon atmosphere. The main gaseous products of CH_3COOH decomposition were CH_4 and CO_2. Moreover, ethane, propane and hydrogen were also detected. The most active photocatalyst towards CH_4 generation was TiO_2 containing 20 wt% of Fe calcinated at 500 °C. The optimum loading of this photocatalyst was 1 g/dm^3. After 5 h of the process the amount of CH_4, CO_2, C_2H_6, C_3H_8 and H_2 evolved was 0.458, 0.450, 0.025, 0.003 and 0.013 mmol, respectively. An increase of CH_3COOH concentration from 0.01 to 1 mol/dm^3 resulted in an increase of methane production. A further increase of CH_3COOH concentration up to 10 mol/dm^3 led to a decrease of the process efficiency. The stability of the prepared photocatalysts against photocorrosion was very high. The amount of dissolved Fe did not exceed 0.17 wt.% of the total Fe present in a catalyst sample.

11/02559 Preparation of PVDF nanofiber composites for hydrogen generation from sodium borohydride

Chinnappan, A. *et al. Energy*, 2011, 36, (2), 755–759.

Nanofibres are able to form a highly porous mesh and their large surface to volume ratio improves performance for many applications. Organic-inorganic polyvinylidene fluoride (PVDF)–cobalt (II) chloride hexahydrate nanofibre composites were prepared by electrospinning method. The structure and physicochemical properties of the novel nanofibre composites are characterized by SEM, EDX and FTIR. The SEM results showed the morphology of the fibres and EDX was given the composition of the nanocomposite catalysts. The nanofibres loaded with metal catalysts are used for the hydrogen production by directly mixing with $NaBH_4$ and water. The novel PVDF nanofibre composites catalyst has shown the stability and given the promising results for the quick production of hydrogen.

11/02560 Ultrahigh figure-of-merit for hydrogen generation from sodium borohydride using ternary metal catalysts

Hu, L. *et al. Journal of Power Sources*, 2011, 196, (1), 69–75.

The authors report further increase in the figure-of-merit (FOM) for hydrogen generation from $NaBH_4$ than reported in an earlier paper, where a sub-nanometre layer of metal catalysts are deposited on carbon nanotube paper (CNT paper) that has been functionalized with polymer-derived silicon carbonitride (SiCN) ceramic film. Ternary, Ru–Pd–Pt, instead of the binary Pd–Pt catalyst used earlier, together with a thinner CNT paper is shown to increase the figure-of-merit by up to a factor of six, putting is above any other known catalyst for hydrogen generation from $NaBH_4$. The catalysts are prepared by first impregnating the functionalized CNT-paper with solutions of the metal salts, followed by reduction in a sodium borohydride solution. The reaction mechanism and the catalyst efficiency are described in terms of an electric charge transfer, whereby the negative charge on the BH_4^- ion is exchanged with hydrogen via the electronically conducting SiCN/CNT substrate.

11/02561 VC_3H_3 organometallic compound: a possible hydrogen storage material

Wadnerkar, N. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 664–670.

This work reports the hydrogen uptake capacity of V-capped and V-inserted VC_3H_3 organometallic complexes using density functional theory (DFT) with different exchange and correlation functionals. Maximum of five and three H_2 molecules are adsorbed on V-capped and V-inserted VC_3H_3 structures, respectively. This corresponds to the hydrogen uptake capacity of 10.07 and 6.66 wt% for the former and the latter, respectively. The first added hydrogen molecule is adsorbed in dihydride form on V-capped as well as V-inserted VC_3H_3 complex. A complex with a dissociated hydrogen molecule adsorbed has higher binding energy than that of molecular hydrogen adsorbed. The nature of interactions between H_2 molecules and organometallic complex is studied using many-body analysis approach. Thermochemistry calculations are performed to see whether H_2 adsorption on V-capped complex is energetically favourable or not for room temperature hydrogen storage.

04 BY-PRODUCTS RELATED TO FUELS

11/02562 A study on the consecutive preparation of silica powders and active carbon from rice husk ash

An, D. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1227–1234.

Rice husk ash (RHA) is an abundant agricultural by-product. The present research work deals with the production of silica powders and active carbon from RHA with a consecutive method. The RHA is firstly treated with acid leaching to remove mineral composition, and then is boiled with base to leach silica. The filtrate is used to synthesize silica powders with CO_2 precipitator and solid residue is used to prepare active carbon. The optimum conditions of preparing silica powders are as follows: the concentration of Na_2CO_3 is 25 wt%, the base-leached time is 4 h, and the impregnation ratio of Na_2CO_3 solution to RHA is 6:1. The yield of silica leached from RHA is 84.57 wt%. The synthesized silica powders are hydrated with amorphous structure, moreover, with a relative smooth surface and high purity. The residue is activated with potassium hydroxide (KOH) after base-leached. The activated carbons are found to be a mixture of micropore and mesopore pore structures. The maximum pore volume, BET surface area and iodine adsorption capacity of as-prepared active carbon can reach 1.22 cm^3/g, 1936.62 m^2/g and 1259.06 mg/g, respectively. Field emission scanning electron microscopy is used to characterize the morphological features of the ash after step-by-step treatment.

11/02563 Activated carbon for hydrogen purification by pressure swing adsorption: multicomponent breakthrough curves and PSA performance

Lopes, F. V. S. *et al. Chemical Engineering Science*, 2011, 66, (3), 303–317.

In this work, multicomponent breakthrough experiments (binary H_2-CO_2, ternary H_2-CO_2-CO and five-component H_2-CO_2-CO-CH_4-N_2) were performed under different operating conditions in activated carbon extrudates to validate the mathematical model. A 10-step one-column VPSA experiment was also performed. These experiments allow experimental validation of adsorption equilibrium predicted by the multicomponent extension of the virial isotherm and a fixed-bed mathematical model. In the VPSA experiment, a 99.981% hydrogen purity stream (with 63 ppm of CO contamination) was obtained with a hydrogen recovery of 81.6% and an adsorbent productivity of $101\,\text{mol}_{H2}\,\text{kg}_{ads}^{-1}\,\text{day}^{-1}$. The mathematical model was also employed to assess the effect of operating conditions and the influence of step times and pressure equalizations in the PSA unit. It was verified that high-purity hydrogen (>99.99%) can be obtained using this adsorbent with recoveries higher than 75% and unit productivities of $160\,\text{mol}_{H2}\,\text{kg}_{ads}^{-1}\,\text{day}^{-1}$.

11/02564 Characterization of spinel and magnetospheres of coal fly ashes collected in power plants in the former USSR

Zyryanov, V. V. *et al. Fuel*, 2011, 90, (2), 486–492.

Six samples of magnetospheres, recovered by magnetic separation from fly ashes, collected from power plants with high temperature boilers in the former USSR, were investigated by combination of instrumental techniques. The phase and chemical compositions, morphology and microstructure of magnetospheres have been studied by optical microscopy, scanning electron microscopy equipped with energy-dispersive X-ray spectroscopy (SEM/EDX), X-ray diffraction (XRD), Mössbauer spectroscopy. Iron in magnetospheres mainly occurs as Fe-spinels, hematite, and iron bearing glass. Structural formulas of spinels promising for catalysis applications were calculated on the base of obtained results. The magnetospheres have been characterized mainly as core–shell nanocomposites from spinel, hematite and quartz crystals in glass matrix divided in high-silica and high-ferrous glasses. The mechanism of magnetospheres formation was proposed.

11/02565 Conversion of almond shell to activated carbons: methodical study of the chemical activation based on an experimental design and relationship with their characteristics

Izquierdo, M. T. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1235–1244.

The objective of this work is to carry out a methodical study of the preparation conditions of almond shell based chemically activated carbons and its influence on the characteristics of the activated carbons. An experimental design was used to optimize the preparation conditions of activated carbons from almond shell via chemical activation with phosphoric acid. Temperatures from 400 to 800 °C, impregnation ratios in the range 0.5–1.5 and carbonization times varying from 30 to 120 min were defined as continuous parameters to be introduced in a simplex mixture experimental design giving a total of 12 experiments to carry out. The response surface methodology was applied in order to study the influence of all the production parameters on the selected responses. The optimization of all the characteristics of the activated carbons under the same experimental conditions is not possible because the influence of activation temperature, impregnation ratio and activation time is different. However using the response surface methodology it is possible to determine the ranges of each experimental preparation condition to obtain optimal characteristics of the activated carbon.

11/02566 Effect of weave tightness and structure on the in-plane and through-plane air permeability of woven carbon fibers for gas diffusion layers

Caston, T. B. *et al. Journal of Power Sources*, 2011, 196, (2), 709–716.

In this study, woven gas diffusion layers (GDLs) with varying weave type and tightness are investigated. Plain and twill weave patterns were manufactured in-house. The in-plane and through-plane air permeability of the woven samples were tested, and mercury intrusion porosimetry (MIP) tests were performed to study the pore structure. It was found that the twill weave has a higher permeability than the plain weave, which is consistent with literature. Like non-woven carbon papers, woven GDLs have higher in-plane permeability than through-plane permeability; however it has been shown that it is possible to manufacture a GDL with higher through-plane permeability than in-plane permeability. It was also concluded that the percentage of macropores in the weave is the driving factor in determining the through-plane air permeability. This work lays the groundwork for future studies to attempt to characterize the relationship between the weave structure and the air permeability in woven GDLs.

05 NUCLEAR FUELS

Scientific, technical

11/02567 A two phase model of high temperature steam-only gasification of biomass char in bubbling fluidized bed reactors using nuclear heat

Gordillo, E. D. and Belghit, A. *International Journal of Hydrogen Energy*, 2011, 36, (1), 374–381.

A two-phase biomass char steam gasification kinetic model is developed in a bubbling fluidized bed with nuclear heat as source of energy. The model is capable of predicting the temperature and concentration profiles of gases in the bubble, emulsion gas and solid phases. The robust model calculates the dynamic and steady state profiles, as well as the complex parameters of fluidized bed. Three pilot scale gasifiers were simulated in order to see the effect of the H/D ratio and the bed heating dynamics in the gasification kinetics, these parameters are found to be really important in order to enhance the water-gas shift reaction, and consequently, the hydrogen production. For the system modelled, hydrogen is the principal product of the steam-only gasification, as reported in the literature data. The carbon dioxide yield seems to be smaller than the ones in other works, but these differences are due principally to the energy source (no combustion is conducted) and that char (no oxygen in the solids) was used as the carbon source.

11/02568 An analysis of development and research on spent nuclear fuel reprocessing

Silverio, L. B. *et al. Energy Policy*, 2011, 39, (1), 281–289.

Nuclear energy comes back to the discussions on the world stage as an energy source that does not contribute to global warming during production process. It can be chosen as the main source of power generation in some countries or complement the energy matrix in others. In this context, there is the need to develop new technologies for the management of radioactive waste generated by the production process. Final repositories for spent fuel are not yet in commercial operation, and techniques for fuel reprocessing have been developed, because after use, the fuel still has materials that produce energy. Some countries already use reprocessing, and develop research to make it more secure and more competitive, while others prefer to adopt policies to prevent developments in this area due to the problem of nuclear proliferation. In another line of research, new reactors are being developed in order to reduce the amount of waste in energy production and some will be designed to work in closed loop, recycling the materials generated.

11/02569 CREAM-based communication error analysis method (CEAM) for nuclear power plant operators' communication

Lee, S. M. *et al. Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 90–97.

Communication error has been considered a primary cause of many incidents and accidents in the nuclear industry. In order to prevent these accidents, a method for the analysis of such communication errors is proposed here. This paper presents a qualitative and a quantitative method to analyse communication errors. The qualitative method focuses on finding a root cause of the communication error and predicting the type of communication error which could happen in nuclear power plants. The authors develop context conditions and antecedent–consequent links of influential factors related to communication errors. The quantitative analysis method focuses on estimating the probability of communication errors. To accomplish the quantification of communication errors, the cognitive speaking process (CSP) is defined and a method to estimate the weighting factors and the probability is suggested. Finally, case studies conducted to validate the applicability of the proposed methods are detailed. From the results, the authors can foresee the effects of given plant conditions on communication errors and reduce the error occurrences.

11/02570 Model for predicting hydroxylamine nitrate stability in plutonium process solutions

Scott Barney, G. and Duval, P. B. *Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 76–84.

A mathematical model is described that may be used to determine the safety of hydroxylamine nitrate (HAN) solutions used in solvent extraction purification of plutonium. The most significant hazard associated with hydroxylamine use in processing plutonium is its rapid, autocatalytic reaction with nitric acid which can result in an explosion or pressurization of process vessels with radiological consequences to humans. In addition, heat is produced by the reaction that could potentially ignite process solvents. The HAN decomposition reaction can occur only under specific process conditions (temperature; HAN, plutonium and nitric acid concentrations) and the model is used to identify these conditions so that they can be avoided. A kinetics model has been developed using all of the known significant reactions that could occur in process solutions containing HAN and nitric acid as well as plutonium and iron. The reaction kinetics data (rate laws, rate constants, activation energies) used in the model were obtained from chemical literature sources. The model shows that the autocatalytic HAN reaction with nitric acid is very rapid and is catalysed by Pu(III) and Fe(II) in process solutions. High temperatures and nitric acid concentrations also promote the reaction.

11/02571 Multi-dimensional computational model of the movement of the solid–gas interface during the layering process in inertial confinement fusion targets in a non-uniform thermal environment

Boehm, K.-J. and Raffray, A. R. *Fusion Engineering and Design*, 2011, 86, (1), 51–65.

The redistribution of deuterium (DD) or of a deuterium–tritium mixture (DT) to form a layer on the inside of spherical inertial confinement fusion (ICF) capsules is a challenging problem because of the symmetry requirements of the fuel layer thickness, the smoothness requirement of the inside target surface, and the time restriction on the production process. Heat- and mass-transfer processes have been identified to interact with one another to influence the outcome of the layering process. For example, the mass redistribution speed of the fuel inside the shell towards a uniform layer and the final layer thickness uniformity depend on the variation in local heat transfer coefficient along the outer target surface. The focus of this work was to develop a numerical tool to help understand the physics involved in the layering process to be able to assess the influence of key parameters on the transient layer formation. The coupled mass and heat transfer processes governing target layering have been studied numerically, implementing unique boundary conditions to track the movement of the gas–solid boundary on the inside of the shell. The model was validated through comparison with theoretical results and laboratory-scale experiments. With this model, a window of parameters can by identified, under which layering experiments are likely to be successful.

11/02572 Nuclear fission sustainability with subcritical reactors driven by external neutron sources

Lafuente, A. and Piera, M. *Annals of Nuclear Energy*, 2011, 38, (4), 910–915.

Although nuclear breeder reactors are a promising way to enhance the potential energy currently retrievable from the uranium reserves, they still have disadvantages because of their safety features (i.e. poor stabilizing mechanisms) and the security of their fuel cycle (diversion of Pu for non-civilian purposes). Loading natural nuclear fuels to a reactor and completely burning them without reprocessing would be ideal, however, this is not possible in critical reactors due to the limitations imposed by the maximum achievable burn-up. An alternative option to attain very high percentages of nuclear natural materials exploitation, while meeting other objectives of nuclear sustainability, could consist of using externally driven subcritical reactors to reach the desired high burn-ups (of the order of 30% and more) without reprocessing. Such scheme would lead to an efficient exploitation of the available raw material, without any risk of proliferation. Exploring this type of reactor concept, this paper analyses the different ways to accomplish this goal while identifying potential setbacks.

11/02573 Numerical simulation of the combined effects of plasma heating and neutron heating loads on the ITER first wall

Zhang, P. *et al. Fusion Engineering and Design*, 2011, 86, (1), 45–50.

To understand the combined effect of plasma heating and neutron heating loadings, the distributions of temperature, stress, and strain in different two-dimensional first wall panel models under normal ITER operation condition were simulated using finite element method. The maximum temperature occurs at the Be armour, and reaches 461 °C. High thermal stresses (in the range of 80–200 MPa) are found at the interface between the Be armour and the CuCrZr layer. The maximum thermal stress reaches 324 MPa in the SS316L cooling tube (20 mm diameter), exceeding its yield strength and resulting in a maximum strain of about 1.7% at the tube inner surface. These simulation results are useful for the design and operation of ITER.

11/02574 Quantitative assessment of radionuclide retention in the Quaternary sediments/granite interface of the Fennoscandian shield (Sweden)

Grandia, F. *et al. Applied Geochemistry*, 2011, 26, (5), 679–687.

The Quaternary sediments representing the interface between the granite host rock and the Earth's surface are of paramount importance when determining the potential cycling of anthropogenic and natural radionuclides in near-surface systems. This is particularly true in the case of high-level nuclear waste (HLNW) repositories placed in granite. In this work a modelling procedure is presented to quantitatively determine the retention capacity of a Quaternary till in the Forsmark area, which has been recently selected to host the deep geologic storage of HLNW in Sweden. Reactive transport numerical models have been used to simulate the intrusion of a deep groundwater carrying radionuclides potentially released from a repository into a Quaternary till. Four radionuclides (^{235}U, ^{135}Cs, ^{226}Ra and ^{90}Sr) have been selected according to their different geochemical behaviour and potential dose relevance to surface ecosystems. Numerical results indicate that: (i) repository-derived U will have a minor impact in the till, mainly due to the high natural concentration of U and its adsorption on ferrihydrite; (ii) repository-derived Cs will be efficiently retained by cation exchange on illite; (iii) repository-derived Ra will be retained via co-precipitation with barite; and although (iv) repository-derived Sr will be retained via co-precipitation with calcite and cation exchange on illite, the retention capacity of the Quaternary till for Sr is limited.

11/02575 Rock damage control in bedrock blasting excavation for a nuclear power plant

Li, H. *et al. International Journal of Rock Mechanics and Mining Sciences*, 2011, 48, (2), 210–218.

Drill and blast is a major method for bedrock excavation in nuclear power plant engineering. Under blasting excavation, blast-induced vibration propagates in rock mass and induces damage to surrounding rock. Studying the characteristics of wave propagation and blast-induced damage to rock mass is most important to restrict the damage extension. In the present paper, in support of the bedrock blasting excavation for the Linao nuclear power plant project, the site seismic survey and sonic wave test are presented to study the characteristics of wave propagation and the blast-induced damage for rock mass. The explosive load, rock damage characteristics and peak particle velocity (PPV) attenuation law are also investigated by numerical simulation using commercial software. It can be seen that the numerical simulation results agree well with that obtained by site monitoring. Based on the site monitoring and the numerical simulation, the relationship between PPV at 30 m away from the charge hole and the damage depth of rock mass is established. A simple method based on safety threshold of vibration velocity for rock mass to restrict the damage depth of rock mass under blasting excavation is presented. According to the damage controlled method and the presented safety threshold of vibration velocity for rock mass, the remained bedrock can be simply and effectively protected during blasting excavation.

Economics, policy, supplies, forecasts

11/02576 Comparison of the transportation risks for the spent fuel in Korea for different transportation scenarios

Jeong, J. *et al. Annals of Nuclear Energy*, 2011, 38, (2–3), 535–539.

According to the long-term management strategy for spent fuels in Korea, they will be transported from the spent fuel pools in each nuclear power plant to the central interim storage facility (CISF) which is to start operation in 2016. At the start of the operation of the final repository (FR), by the year 2065, transport will then take place between the CISF and the FR. Therefore, safe and economical logistics are needed for the transportation of these spent fuels by considering their transportation risks and costs. This study developed four transportation scenarios for a maritime transportation by considering the type of transportation casks and transport means in order to suggest safe and economical transportation logistics for the spent fuels in Korea. The transportation risks for these four transportation scenarios were estimated and compared, as well as the transportation risks resulting from accidents during the transportation of PWR and PHWR spent fuels by road trailers from the CISF and the FR. From the results of this study, the risks resulting from accidents during the transportation of the spent fuels have a very low radiological risk activity with a manageable safety and health consequences. The results of this study can be used as basic data for the development of safe and economical logistics for a transportation of the spent fuels in Korea by considering the transportation costs for the four scenarios which will be needed in the near future.

11/02577 Is China ready for its nuclear expansion?

Zhou, Y. *et al. Energy Policy*, 2011, 39, (2), 771–781.

China's rapid pace of nuclear energy growth is unique, and its impact on the global nuclear market as both a customer and potential future supplier is already tremendous and will continue to expand. It is crucial to understand this energy policy development and its impact on various global areas. Unfortunately, there is relatively limited English-language information available about China's nuclear power industry and its current development. This paper aims to provide a comprehensive assessment of the Chinese nuclear energy program and policy, reviewing its past, present, likely future developments, as well as to consider potential challenges that deserve further attention. This paper will explore reasons that have caused the existing industry, describe China's nuclear bureaucracy and decision making process to understand how different stakeholders play a role in China's nuclear energy development. This study concludes that China's existing nuclear program and industry, in combination with its current stable economic and political environment, provides a sound foundation for the planned nuclear expansion. However, challenges which are crucial to the success of the nuclear expansion will need to be addressed.

11/02578 Nuclear energy consumption, oil prices, and economic growth: evidence from highly industrialized countries

Lee, C.-C. and Chiu, Y.-B. *Energy Economics*, 2011, 33, (2), 236–248.

This study utilizes the Johansen cointegration technique, the Granger non-causality test of Toda and Yamamoto, the generalized impulse response function, and the generalized forecast error variance decomposition to examine the dynamic interrelationship among nuclear energy consumption, real oil price, oil consumption, and real income in six highly industrialized countries for the period 1965–2008. Empirical results indicate that the relationships between nuclear energy consumption and oil are as substitutes in the USA and Canada, while they are complementary in France, Japan, and the UK. Second, the long-run income elasticity of nuclear energy is larger than one, indicating that nuclear energy is a luxury good. Third, the results of the Granger causality test find evidence of unidirectional causality running from real income to nuclear energy consumption in Japan. A bidirectional relationship appears in Canada, Germany and the UK, while no causality exists in France and the USA. Evidence of causality is found running from real oil price to nuclear energy consumption, except for the USA, and causality running from oil consumption to nuclear energy consumption in Canada, Japan, and the UK, suggesting that changes in price and consumption of oil influence nuclear energy consumption. Finally, the results observe transitory initial impacts of innovations in real income and oil consumption on nuclear energy consumption. In the long run the impact of real oil price is relatively larger compared with that of real income on nuclear energy consumption in Canada, Germany, Japan, and the USA.

11/02579 Ready for nuclear energy?: an assessment of capacities and motivations for launching new national nuclear power programs

Jewell, J. *Energy Policy*, 2011, 39, (3), 1041–1055.

The International Atomic Energy Agency reports that as of July 2009 there were 52 countries interested in building their first nuclear power plant. This paper characterizes and evaluates these 'newcomer countries' in terms of their capacity and motivations to develop nuclear power. It quantifies factors historically associated with the development of nuclear energy programs and then benchmarks the newcomers against these data. Countries with established nuclear power programs, particularly where nuclear facilities are privately owned, are typically larger, wealthier and politically stable economies with high government effectiveness. Nuclear power was historically launched during periods of high electricity consumption growth. Other indicators for the potential of nuclear power include: the size of the national grid, the presence of international grid connections and security of fuel supply for electricity production. The authors identify 10 newcomers which most closely resemble the established nuclear power countries and thus are most likely to deploy nuclear energy, 10 countries where the development of nuclear energy is uncertain due to high political instability, 14 countries with lower capacities where pursuing nuclear energy may require especially strong international cooperation and 18 countries where the development of nuclear power is less likely due to their significantly lower capacities and motivations.

11/02580 Real options valuation of fusion energy R&D programme

Bednyagin, D. and Gnansounou, E. *Energy Policy*, 2011, 39, (1), 116–130.

This paper aims to perform a real options valuation of fusion energy research and development (R&D) programme. Strategic value of thermonuclear fusion technology is estimated here based on the expected cash flows from construction and operation of fusion power plants and the real options value arising due to managerial flexibility and the underlying uncertainty. First, a basic investment option model of Black–Scholes type is being considered. Then, a fuzzy compound real R&D option model is elaborated, which reflects in a better way the multi-stage nature of the programme and takes into account the imprecision of information as one of the components of the overall programme uncertainty. Two different strategies are compared: 'Baseline' corresponding to a relatively moderate pace of fusion research, development, demonstration and deployment activities vs 'Accelerated' strategy, which assumes a rapid demonstration and massive deployment of fusion. The conclusions are drawn from the model calculations regarding the strategic value of fusion energy R&D and the advantages of accelerated development path.

11/02581 The influence of nuclear generation on CO_2 emissions and on the cost of the Spanish system in long-term generation planning

Delgado, F. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 673–683.

This paper presents the influence of a nuclear generation option on CO_2 emissions and on the cost of the Spanish long-term generation system by means of the development of a stochastic linear model, based on the software GAMS, where multiple aspects have been contemplated: the uncertainty regards fossil fuel and CO_2 emission allowance prices by analysing different scenarios, the stability and supply security of the system by considering different restrictions, the maximum grade of penetration of the different technologies by means of commissioning plans, etc. Only two of the conclusions drawn are focused on here. First, it is possible to get a clean system without nuclear power generation but the cost would be higher than in the case where the existing nuclear power plants continue to operate. Second, the development of clean coal technologies could be affected negatively by the development of nuclear generation.

11/02582 Toward a viable nuclear waste disposal program

Schaffer, M. B. *Energy Policy*, 2011, 39, (3), 1382–1388.

This paper deals with the lack of a suitable permanent storage site for the radioactive waste that has been produced by more than 103 open-cycle nuclear reactors in the USA. The US Department of Energy (DOE) has recently withdrawn the licensing application for the Yucca Mountain Repository leaving the nuclear industry responsible for the safety of more than 800 waste-containing concrete casks currently on the open surface at 34 sites. It also has not undertaken measures to reduce the volume of additional waste produced by both existing and newly planned reactors. The DOE has instead opted to undertake research to develop new cycles that 'burn' the radioactive waste. This policy appears subordinated to obvious political pressures. It is short sighted in terms of a practical program to serve the interests of the clean and safe energy requirements of the country. The paper also describes technical initiatives and processes that are recommended for a better solution.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

11/02583 A methodology for analysis of impacts of grid integration of renewable energy

George, M. and Banerjee, R. *Energy Policy*, 2011, 39, (3), 1265–1276.

Present electricity grids are predominantly thermal (coal, gas) and hydro based. Conventional power planning involves hydro-thermal scheduling and merit order dispatch. In the future, modern renewables (hydro, solar and biomass) are likely to have a significant share in the power sector. This paper presents a method to analyse the impacts of renewables in the electricity grid. A load duration curve based approach has been developed. Renewable energy sources have been treated as negative loads to obtain a modified load duration curve from which capacity savings in terms of base and peak load generation can be computed. The methodology is illustrated for solar, wind and biomass power for Tamil Nadu (a state in India). The trade-offs and interaction between renewable sources are analysed. The impacts on capacity savings by varying the wind regime have also been shown. Scenarios for 2021–2022 have been constructed to illustrate the methodology proposed. This technique can be useful for power planners for an analysis of renewables in future electricity grids.

11/02584 A novel business model for aggregating the values of electricity storage

He, X. *et al. Energy Policy*, 2011, 39, (3), 1575–1585.

Electricity storage is considered as a valuable source of flexibility with applications covering the whole electricity value chain. Most of the existing evaluation methods for electricity storage are conceived for one specific use of the storage, which often leads to the conclusion that the investment on storage does not pay off. However, the value of storage cannot be properly estimated without taking into account the possibility of aggregating the services that storage can offer to different actors. This paper proposes a new business model that allows aggregating multiple revenue streams of electricity storage in a systematic way. The model consists in coordinating a series of auctions in which the right to utilize the storage unit is auctioned upon different time horizons. In the mean time, non-conflicting usage of storage by the actors in these different auctions is ensured. The functioning of the model is demonstrated by a case study. The results show that a storage unit can achieve higher return on investment in the manner proposed in the business model.

11/02585 Combining of direct search and signal-to-noise ratio for economic dispatch optimization

Lin, W.-M. *et al. Energy Conversion and Management*, 2011, 52, (1), 487–493.

This paper integrated the ideas of direct search and signal-to-noise ratio (SNR) to develop a novel direct search (NDS) method for solving the non-convex economic dispatch problems. NDS consists of three stages: direct search (DS), global SNR (GSNR) and marginal compensation (MC) stages. DS provides a basic solution. GSNR searches the point with optimization strategy. MC fulfils the power balance requirement. With NDS, the infinite solution space becomes finite. Furthermore, a same optimum solution can be repeatedly reached. Effectiveness of NDS is demonstrated with three examples and the solutions were compared with previously published results. Test results show that the proposed method is simple, robust, and more effective than many other previously developed algorithms.

11/02586 Development of a real time energy monitoring platform

Bayindir, R. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (1), 137–146.

This study introduces development of a user-friendly and quite effectual energy monitoring system which has been installed in Electrical Education Department of Gazi University in Turkey and in use since November 2007. The system developed monitors data in real time using a powerful energy analyser which is capable of measuring many parameters of energy consumed in the building. The real time data measured by the power analyser are transferred to a host computer via RS485 serial communication protocol and then collected in a database continuously. Thus, parameters of energy measured are successfully followed, archived, and presented as graphical forms. The monitoring system presented in the study integrates to quite visual and quite user friendly interface with powerful and flexible hardware. Therefore, several functions can be performed easily and safely by simple actions. On the other hand, the system presented in this paper is developed in a university, so it can be used by students to learn energy systems and parameters.

11/02587 DG allocation with application of dynamic programming for loss reduction and reliability improvement

Khalesi, N. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (2), 288–295.

Distribution system companies intend to supply electricity to its customers in an economical and reliable manner whereas customers in most distribution system are outspread and connect to distribution system with different type of equipments. These equipment usually have various types and resistance together, that produce highest loss and lowest reliability for distribution systems and customers that are not appreciated in networks. Distributed generations (DGs) are one of the best reliable solutions for these problems if they are allocated appropriately in the distribution system. This paper presents multi-objective function to determine the optimal locations to place DGs in distribution system to minimize power loss of the system and enhance reliability improvement and voltage profile. Time varying load is applied in this optimization to reach pragmatic results meanwhile all of the study and their requirement are based on cost/benefit forms. Finally to solve this multi-objective problem a novel approach based on dynamic programming is used. The proposed methodology is successfully applied to a study case and simulation results are reported to verify the proposed approach.

11/02588 Dynamic performance enhancement of microgrids by advanced sliding mode controller

Abdollahi Sofla, M. and Gharehpetian, G. B. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (1), 1–7.

Dynamics are the most important problems in the microgrid operation. In the islanded microgrid, the mismatch of parallel operations of inverters during dynamics can result in the instability. This paper considers severe dynamics which can occur in the microgrid. Microgrid can have different configurations with different load and generation dynamics which are facing voltage disturbances. As a result, microgrid has many uncertainties and is placed in the distribution network where is full of voltage disturbances. Moreover, characteristics of the distribution network and distributed energy resources in the islanded mode make microgrid vulnerable and easily lead to instability. The main aim of this paper is to discuss the suitable mathematical modelling based on microgrid characteristics and to design properly inner controllers to enhance the dynamics of microgrid with uncertain and changing parameters. This paper provides a method for inner controllers of inverter-based distributed energy resources to have a suitable response for different dynamics. Parallel inverters in distribution networks were considered to be controlled by non-linear robust voltage and current controllers. Theoretical prove beyond simulation results, reveal evidently the effectiveness of the proposed controller.

11/02589 Maximizing production rate and workload smoothing in assembly lines using particle swarm optimization

Nearchou, A. C. *International Journal of Production Economics*, 2011, 129, (2), 242–250.

Particle swarm optimization (PSO) one of the latest developed population heuristics has rarely been applied in production and operations management (POM) optimization problems. A possible reason for this absence is that, PSO was introduced as global optimizer over continuous spaces, while a large set of POM problems are of combinatorial nature with discrete decision variables. PSO evolves floating-point vectors (called particles) and thus, its application to POM problems whose solutions are usually presented by permutations of integers is not straightforward. This paper presents a novel method based on PSO for the simple assembly line balancing problem (SALBP), a well-known NP-hard POM problem. Two criteria are simultaneously considered for optimization: to maximize the production rate of the line (equivalently to minimize the cycle time), and to maximize the workload smoothing (i.e. to distribute the workload evenly as possible to the workstations of the assembly line). Emphasis is given on seeking a set of diverse Pareto optimal solutions for the bi-criteria SALBP. Extensive experiments carried out on multiple test-beds problems taken from the open literature are reported and discussed. Comparisons between the proposed PSO algorithm and two existing multi-objective population heuristics show a quite promising higher performance for the proposed approach.

11/02590 Measured performance of a 1.72 kW rooftop grid connected photovoltaic system in Ireland

Ayompe, L. M. *et al. Energy Conversion and Management*, 2011, 52, (2), 816–825.

This paper presents results obtained from monitoring a 1.72 kW_p photovoltaic system installed on a flat roof of a 12 m high building in Dublin, Ireland (latitude 53.4°N and longitude 6.3°E). The system was monitored between November 2008 and October 2009 and all the electricity generated was fed into the low voltage supply to the building. Monthly average daily and annual performance parameters of the PV system evaluated include: final yield, reference yield, array yield, system losses, array capture losses, cell temperature losses, PV module efficiency, system efficiency, inverter efficiency, performance ratio and capacity factor. The maximum solar radiation, ambient temperature and PV module temperature recorded were 1241 W/m^2 in March, 29.5 °C and 46.9 °C in June respectively. The annual total energy generated was 885.1 kW h/kW_p while the annual average daily final yield, reference yield and array yield were 2.41 kW h/kW_p/day, 2.85 kW h/kW_p/day and 2.62 kW h/kW_p/day respectively. The annual average daily PV module efficiency, system efficiency and inverter efficiency were 14.9%, 12.6% and 89.2% respectively while the annual average daily performance ratio and capacity factor were 81.5% and 10.1% respectively. The annual average daily system losses, capture losses and cell temperature losses were 0.23 h/day, 0.22 h/day and 0.00 h/day respectively. Comparison of this system with other systems in different locations showed that the system had the highest annual average daily PV module efficiency, system efficiency and performance ratio of 14.9%, 12.6% and 81.5% respectively. The PV system's annual average daily final yield of 2.4 kW h/kW_p/day is higher than those reported in Germany, Poland and Northern Ireland. It is comparable to results from some parts of Spain but it is lower than the reported yields in most parts of Italy and Spain. Despite low insolation levels, high average wind speeds and low ambient temperature improve Ireland's suitability.

11/02591 Metamorphoses of cogeneration-based district heating in Romania: a case study

Iacobescu, F. and Badescu, V. *Energy Policy*, 2011, 39, (1), 269–280.

The paper presents the birth and evolution of the cogeneration-based district heating (DH) system in Targoviste, a medium-sized city in Romania. The evolution of the industrialization degree was the main factor which controlled the population growth and led to a continuous reconfiguration of the DH system. The DH system assisted by cogeneration emerged as a solution in a certain phase of the demographic development of the city. The political and social changes occurring in Romania after 1990 have had important negative consequences on the DH systems in small towns. In Targoviste the DH system survived but in 2001 the solution based on cogeneration became economically inefficient, due to the low technical quality of the existing equipment and the low gas prices, to the procedure of setting the DH tariffs and the service cost at consumer's level and to some bureaucratic problems. Energy policy measures taken at national and local levels in 2003 and 2005 led to the re-establishment of the cogeneration-based district heating in 2005. However, a different technical solution has been adopted. Details about the present (2009) cogeneration-based DH system in Targoviste are presented together with several technical and economical indicators. The main conclusion is that by a proper amendment of the technical solutions, cogeneration could be a viable solution for DH even in case of abrupt social and demographic changes, such as those occurring in Romania after 1990.

11/02592 Modeling and analysis of an aluminum–water electrochemical generator for simultaneous production of electricity and hydrogen

Wang, H. Z. *et al. International Journal of Energy Research*, 2011, 35, (1), 44–51.

Recently the use of aluminium as anodes for the combined production of electric energy and hydrogen has been considered. This study has taken this idea forward and developed a mathematical model for a simplified aluminium–water electrochemical co-generator. The result was a reasonable agreement between the model predictions and experimental data. Various factors, including the geometric parameters, electrolyte feeding velocity as well as electrode kinetics, were examined for the aluminium–water electrochemical co-generator based on the modelling equations. Some critical values for the future design of the aluminium–water co-generator were also proposed.

11/02593 Multilevel converters control for renewable energy integration to the power grid

Pouresmaeil, E. *et al. Energy*, 2011, 36, (2), 950–963.

The paper deals with the multilevel converters control strategy for renewable energy resources integration in distribution grids. The proposed control scheme ensures the injection of the generated power in the distribution grid with fast dynamic response, while providing an additional active power filtering capability providing the required harmonic and reactive currents to the considered non-linear loads. The proposed control scheme is applicable to a general multilevel converter and to any types of the renewable energy resources. The control scheme is validated by means of simulations with a three-level diode-clamped converter which interfaces a wind power generation system to a distribution grid supplying non-linear loads. From extensive simulation results, high performance of this control strategy in renewable energy application is demonstrated with reduced total harmonic distortion, increased power factor and compensated load's reactive powers.

11/02594 Oxide-based thermoelectric power generation module using *p*-type $Ca_3Co_4O_9$ and *n*-type $(ZnO)_7In_2O_3$ legs

Choi, S.-M. *et al. Energy Conversion and Management*, 2011, 52, (1), 335–339.

This study presents the fabrication of an oxide-based thermoelectric power generation module using layer-structured *p*-type $Ca_3Co_4O_9$ and *n*-type $(ZnO)_7In_2O_3$ legs. The potential for development and effective use of high power density thermoelectric generation system is investigated in terms of its power per area, the temperature conditions, and the number of *p–n* couples. The significance of the manufacturing factors including contact between legs and electrodes are discussed. The thermoelectric figure of merit values of the *p*-type and *n*-type legs at 1100 K were $0.55 \times 10^{-4}\,K^{-1}$ and $1.35 \times 10^{-4}\,K^{-1}$, respectively. The maximum power obtained was 423 mW with the 44 *p–n* couples module, under the thermal condition of a hot-side temperature of 1100 K and a temperature difference $\Delta T = 673$ K.

11/02595 Reducing life cycle greenhouse gas emissions of corn ethanol by integrating biomass to produce heat and power at ethanol plants

Kaliyan, N. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1103–1113.

A life-cycle assessment (LCA) of corn ethanol was conducted to determine the reduction in the life-cycle greenhouse gas (GHG) emissions for corn ethanol compared to gasoline by integrating biomass fuels to replace fossil fuels (natural gas and grid electricity) in a US Midwest dry-grind corn ethanol plant producing $0.19\,hm^3\,y^{-1}$ of denatured ethanol. The biomass fuels studied are corn stover and ethanol co-products [dried distillers grains with solubles (DDGS), and syrup (solubles portion of DDGS)]. The biomass conversion technologies/systems considered are process heat (PH) only systems, combined heat and power (CHP) systems, and biomass integrated gasification combined cycle (BIGCC) systems. The life-cycle GHG emission reduction for corn ethanol compared to gasoline is 38.9% for PH with natural gas, 57.7% for PH with corn stover, 79.1% for CHP with corn stover, 78.2% for IGCC with natural gas, 119.0% for BIGCC with corn stover, and 111.4% for BIGCC with syrup and stover. These GHG emission estimates do not include indirect land use change effects. GHG emission reductions for CHP, IGCC, and BIGCC include power sent to the grid which replaces electricity from coal. BIGCC results in greater reductions in GHG emissions than IGCC with natural gas because biomass is substituted for fossil fuels. In addition, underground sequestration of CO_2 gas from the ethanol plant's fermentation tank could further reduce the life-cycle GHG emission for corn ethanol by 32% compared to gasoline.

11/02596 Techno-economic appraisal of fossil-fuelled power generation systems with carbon dioxide capture and storage

Hammond, G. P. *et al. Energy*, 2011, 36, (2), 975–984.

Carbon capture and storage (CCS) facilities coupled to power plants provide a climate change mitigation strategy that potentially permits the continued use of fossil fuels while reducing the carbon dioxide (CO_2) emissions. This process involves three basic stages: capture and compression of CO_2 from power stations, transport of CO_2, and storage away from the atmosphere for hundreds to thousands of years. Potential routes for the capture, transport and storage of CO_2 from UK power plants are examined. Six indicative options are evaluated, based on 'pulverized coal', 'natural gas combined cycle', and 'integrated (coal) gasification combined cycle' power stations. Chemical and physical CO_2 absorption capture techniques are employed with realistic transport possibilities to 'enhanced oil recovery' sites or depleted gas fields in the North Sea. The selected options are quantitatively assessed against well-established economic and energy-related criteria. Results show that CO_2 capture can reduce emissions by over 90%. However, this will reduce the efficiency of the power plants concerned, incurring energy penalties between 14 and 30% compared to reference plants without capture. Costs of capture, transport and storage are concatenated to show that the whole CCS chain 'cost of electricity' (COE) rises by 27–142% depending on the option adopted. This is a significant cost increase, although calculations show that the average 'cost of CO_2 captured' is £15/tCO_2 in 2005 prices (the current base year for official UK producer price indices). If potential governmental carbon penalties were introduced at this level, then the COE would equate to the same as the reference plant, and make CCS a viable option to help mitigate large-scale climate change.

Economics, policy, supplies, forecasts

11/02597 A cooling change-point model of community-aggregate electrical load

Ali, M. T. *et al. Energy and Buildings*, 2011, 43, (1), 28–37.

Estimates of daily electrical cooling load for a city of 800,000 are developed based on the relationship between weather variables and daily-average electricity consumption over 1 year. The relationship is found to be nearly linear above a threshold temperature. Temperature and humidity were found to be the largest, at 59%, and second largest, at 21%, contributors to electrical cooling load. Direct normal irradiation intercepted by a vertical cylinder, DNI $\sin\theta$, was found to be a useful explanatory variable when modelling aggregates of buildings without a known or dominant orientation. The best study case model used DNI $\sin\theta$ and diffuse horizontal irradiation (DHI) as distinct explanatory variables with annual electrical cooling load contributions of 9% and 11% respectively. Although the seasonal variation in electrical cooling load is large – on peak summer days more than 1.5 times the winter base load – the combined direct and diffuse solar contribution is essentially flat through the year, a condition at odds with the common assumption that solar cooling always provides a good match between supply and demand. The final model gives an electrical cooling load estimate for Abu Dhabi Island that corresponds to 40% of the total annual electrical load and 61% on the peak day.

11/02598 A novel evolutionary algorithm for dynamic economic dispatch with energy saving and emission reduction in power system integrated wind power

Liao, G.-C. *Energy*, 2011, 36, (2), 1018–1029.

An optimization algorithm is proposed in this paper to solve the economic dispatch problem that includes wind farm using the chaotic quantum genetic algorithm. In addition to the detailed models of economic dispatch introduction and their associated constraints, the wind power effect is also included in this paper. The chaotic quantum genetic algorithm used to solve the economic dispatch process and discussed with real scenarios used for the simulation tests. After comparing the proposed algorithm with several other algorithms commonly used to solve optimization problems, the results show that the proposed algorithm is able to find the optimal solution quickly and accurately (i.e. to obtain the minimum cost for power generation in the shortest time). At the end, the impact to the total cost savings for power generation after adding (or not adding) wind power generation is also discussed. The actual implementation results prove that the proposed algorithm is economical, fast and practical. They are quite valuable for further research.

11/02599 A novel modeling approach for hourly forecasting of long-term electric energy demand

Filik, Ü. B. *et al. Energy Conversion and Management*, 2011, 52, (1), 199–211.

In this study, a novel mathematical method is proposed for modelling and forecasting electric energy demand. The method is capable of making long-term forecasts. However, unlike other long-term forecasting models, the proposed method produces hourly results with improved accuracy. The model is constructed and verified using 26-year-long real-life load data (4 years with hourly resolution) obtained from the Turkish Electric Power Company. The overall method consists of a nested combination of three sub-sections for modelling. The first section is the coarse level for modelling variations of yearly average loads. The second section refines this structure by modelling weekly residual load variations within a year. The final section reaches to the hourly resolution by modelling variations within a week, using a novel two-dimensional mathematical representation at this resolution. The adoptions of such nested forecasting methodology together with the proposed two-dimensional representation for hourly load constitute the novelties of this work. The major advantage of the proposed approach is that it enables the possibility of making short-, medium-, and long-term hourly load forecasting within a single framework. Several mathematical functions are applied as models at each level of the nested system for achieving the minimal forecasting error. Proposed model functions with their corresponding forecasting accuracies are presented in terms of root mean square error and mean absolute percentage error.

11/02600 Analysis of major failures in Europe's power grid

Rosas-Casals, M. and Solé, R. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 805–808.

Power grids are prone to failure. Time series of reliability measures such as total power loss or energy not supplied can give significant account of the underlying dynamical behaviour of these systems, specially when the resulting probability distributions present remarkable features such as an algebraic tail, usually considered the footprint of self-organization and the existence of critical points. In this paper, 7 years (from 2002 to 2008) of Europe's transport of electricity network failure events have been analysed and the best fit for this empirical data probability distribution is presented. With the actual span of available data and although there exists a moderate support for the power-law model, the relatively small amount of events contained in the function's tail suggests that causal factors other than self-organization or a critical state might be significantly ruling these systems' dynamics.

11/02601 Annual electricity consumption analysis and forecasting of China based on few observations methods

Meng, M. and Niu, D. *Energy Conversion and Management*, 2011, 52, (2), 953–957.

The annual electricity consumption analysis and forecasting of China is one of the important bases of management decision making for power generation groups as well as power policy adjusting for government. The socioeconomic actuality could not offer adequate observations with perfect statistic characters. The partial least squares method is applied to get a linear equation. It could quantificational simulate the relationship between the electricity consumption and its factors. The variables importance analysis method is further adopted to distinguish the explanatory power of all relative factors. The foremost importance of production and consumption in rural area shows that the development of this area should account more for the increasing of electricity consumption. The less explanatory power of the gross domestic product of tertiary industry means the gigantic potential in electricity consumption for the future several years. At last, it calculates the contributions of observations. The results show that the unusual development of real estate and relative industry has affected the usual electricity consumption mode. With the clear away of price bubble in real estate, the increasing speed of electricity consumption will slow down in the recent years.

11/02602 Causal modeling and inference for electricity markets

Ferkingstad, E. *et al. Energy Economics*, 2011, 33, (3), 404–412.

How does dynamic price information flow among Northern European electricity spot prices and prices of major electricity generation fuel sources? The authors use time series models combined with new advances in causal inference to answer these questions. Applying the methods to weekly Nordic and German electricity prices, and oil, gas and coal prices, with German wind power and Nordic water reservoir levels as exogenous variables, the authors estimate a causal model for the price dynamics, both for contemporaneous and lagged relationships. In contemporaneous time, Nordic and German electricity prices are interlinked through gas prices. In the long run, electricity prices and British gas prices adjust themselves to establish the equilibrium price level, since oil, coal, continental gas and euro/US dollar exchange ratios are found to be weakly exogenous.

11/02603 Common failures of demand response

Kim, J.-H. and Shcherbakova, A. *Energy*, 2011, 36, (2), 873–880.

Demand response (DR) programs have recently become popular means of mitigating excessive claims on regional electricity networks and providing more reliable access to electric power. Many countries have experimented with DR pilot programs and some are beginning to incorporate similar schemes as permanent elements of the electricity sector. However, DR remains an experimental technique in much of the world as programs frequently fail to meet their goals and reach their potential. This paper examines the central structural and behavioural obstacles to success of DR programs and outlines some potential solutions which could greatly improve the functionality and success of such programs in the future.

11/02604 Development of micro power generators – a review

Chou, S. K. *et al. Applied Energy*, 2011, 88, (1), 1–16.

The demand for energy sources that are compact, lightweight and powerful has significantly increased in recent years. Traditional chemical batteries that are highly developed are unable to meet the demand for high energy intensity. This gap is expected to widen in the future as electronic devices need more power to support enhanced functionalities. Hydrocarbon fuels have energy densities much greater than the best batteries. Therefore, taking advantage of the high energy density of chemical fuels to generate power becomes an attractive technological alternative to batteries. To address the growing demand for smaller scale and higher energy density power sources, various combustion-based micro power generators are being developed around the world. This paper provides an update on recent progresses and developments in micro-scale combustion and micro power generators. The paper, broadly divided into four main sections, begins with a review of various methods to enhance and stabilize the combustion at micro-scale, subsequently improving the efficiency. This is followed by a description of various micro-thermophotovoltaic power generators. The third section focuses on MEMS (microelectromechanical systems)-based solid propellant micro-propulsion systems. Finally, a brief review is made to other micro power generators.

11/02605 Does electricity consumption panel Granger cause GDP? A new global evidence

Narayan, P. K. *et al. Applied Energy*, 2010, 87, (10), 3294–3298.

This paper undertook a panel data investigation of long-run Granger causality between electricity consumption and real GDP for seven panels, which together consist of 93 countries. A new panel causality test was used and it was found that in the long-run both electricity consumption and real GDP have a bidirectional Granger causality relationship except for the Middle East where causality runs only from GDP to electricity consumption. Finally, for the G6 panel the estimates revealed a negative sign effect, implying that increasing electricity consumption in the six most industrialized nations will reduce GDP.

11/02606 Electricity demand price elasticity in China based on computable general equilibrium model analysis

He, Y. X. *et al. Energy*, 2011, 36, (2), 1115–1123.

Based on the computable general equilibrium (CGE) model, this paper simulates the impact of electricity price adjustment on demand for electricity, and the simulation results show the range of electricity elasticities of different consumers. The elasticities of the high power-consuming sectors are relatively larger. However, the absolute values of the price elasticities are less than one. Furthermore, this paper quantitatively analyses the price elasticity of different categories of users, which are classified according to the objectives of China's electricity price reform. The elasticity absolute value of industry and commerce is around 0.018, that of residents is around 0.300 and that of agriculture is around 0.066. Finally, the price elasticities of different consumers in 2005 and 2007 are calculated through the CGE model, and it is discovered that the price elasticity absolute values in 2007 are less than that in 2005. The analytical results of this paper can provide corresponding support for the formulation of electricity pricing mechanisms for the developing countries.

11/02607 Electricity price forecasting using artificial neural networks

Singhal, D. and Swarup, K. S. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 550–555.

Electricity price forecasting in deregulated open power markets using neural networks is presented. Forecasting electricity price is a challenging task for on-line trading and e-commerce. Bidding competition is one of the main transaction approaches after deregulation. Forecasting the hourly market-clearing prices (MCP) in daily power markets is the most essential task and basis for any decision making in order to maximize the benefits. Artificial neural networks are found to be most suitable tool as they can map the complex interdependencies between electricity price, historical load and other factors. The neural network approach is used to predict the market behaviours based on the historical prices, quantities and other information to forecast the future prices and quantities. The basic idea is to use history and other estimated factors in the future to 'fit' and 'extrapolate' the prices and quantities. A neural network method to forecast the market-clearing prices (MCPs) for day-ahead energy markets is developed. The structure of the neural network is a three-layer back propagation (BP) network. The price forecasting results using the neural network model shows that the electricity price in the deregulated markets is dependent strongly on the trend in load demand and clearing price.

11/02608 Eliciting public support for greening the electricity mix using random parameter techniques

Grösche, P. and Schröder, C. *Energy Economics*, 2011, 33, (2), 363–370.

With its commitment to double the share of renewable fuels in electricity generation to at least 30% by 2020, the German government has embarked on a potentially costly policy course whose public support remains an open empirical question. Building on household survey data, in this paper the authors assess people's willingness-to-pay (WTP) for various fuel mixes in electricity generation, and capture preference heterogeneity among respondents using random parameter techniques. Based on the estimates, the authors trace out the locus that links the premia charged for specific electricity mixes with the fraction of people supporting the policy. Albeit people's WTP for a certain fuel mix in electricity generation is positively correlated to the renewable fuel share, the results imply that the current surcharge effectively exhausts the financial scope for subsidizing renewable fuels.

11/02609 Estimation of tourism-induced electricity consumption: the case study of Balearics Islands, Spain

Bakhat, M. and Rosselló, J. *Energy Economics*, 2011, 33, (3), 437–444.

Tourism has started to be acknowledged as a significant contributor to the increase in environmental externalities, especially to climate change. Various studies have started to estimate and compute the role of the different tourism sectors' contributions to greenhouse gas emissions. These estimations have been made from a sectoral perspective, assessing the contribution of air transport, the accommodation sector, or other tourism-related economic sectors. However, in order to evaluate the impact of this sector on energy use the approaches used in the literature consider tourism in its disaggregated way. This paper assesses the electricity demand pattern and investigates the aggregated contribution of tourism to electricity consumption using the case study of the Balearic Islands (Spain). Using a conventional daily electricity demand model, including data for daily stocks of tourists the impact of the different population growth rate scenarios on electricity loads is also investigated. The results show that, in terms of electricity consumption, tourism cannot be considered a very energy-intensive sector.

11/02610 Extending market activities for a distribution company in hourly-ahead energy and reserve markets – part I: problem formulation

Mashhour, M. *et al. Energy Conversion and Management*, 2011, 52, (1), 477–486.

This work presents a novel hourly-ahead profit model for an active distribution company (DISCO), a DISCO with high capacity level of connected DGs that can make selling proposals for the markets, in a pool-based system. The presented model engages DISCO in both energy producing and reserve providing activities. DISCO's earnings from reserve market include the remuneration both for real-time generation and ready-for-service capacity. To achieve the optimal decisions for an active DISCO in the energy and reserve markets, a two-stage optimization model and associated mathematical formulations have been developed. The first subproblem extracts a single operating profile (a lumped financial model) of the whole distribution system, including DGs and ILs, at the connecting point to the upstream network. The second one determines the optimal values of decision variables (power and reserve commodities) to maximize the DISCO's profit, in case such variables are accepted in the markets. In other words, it aims to optimally allocate the DISCO's generating capability for proposing into the energy and reserve markets, from the DISCO's perspective. It also proposes a profit-based network reconfiguration methodology for a multi-substation multi-feeder DISCO to increase the DISCO's ability to gain more benefits from the market activities. It conducts DISCO's generating capabilities towards the proper substations to reap more probable benefits. It also introduces fast, simple, and straightforward algorithms for recognition and removal of configurations having loop and/or islanding parts. Simulation results are given at the second part of the present work.

11/02611 Extending market activities for a distribution company in hourly-ahead energy and reserve markets – part II: numerical results

Mashhour, M. *et al. Energy Conversion and Management*, 2011, 52, (1), 569–580.

The present work is to show the application and implementation of the algorithms and models proposed in part I. It also represents the simulation results of (a) extracting a lumped financial model (the aggregated model) of the distribution system with distributed generations (DGs) and interruptible loads (ILs), (b) distribution company's (DISCO's) process of decision-making, based on the created financial model, on allocating its generating capability for internal usage and proposing to the hourly-ahead energy and reserve markets, and (c) a profit-based network reconfiguration methodology that increases the DISCO's technical ability and directs its financial affairs towards more profitable transactions in the upcoming markets. The function of the algorithms used for detecting unfeasible configurations, namely loop path and/or isolated part in the network are shown and well exemplified. Influential factors in DISCO's generating capability and in the coefficients of DISCO's internal cost function (ICF) are investigated. The present study substantiates the ICF-based optimization method by comparing the relevant results with the results obtained based on the use of total cost function (TCF). Several scenarios on market prices of energy and reserve and on the contingency probability factor pertaining to the real-time generation in reserve market are considered. Simulation results indicate that getting more economical benefits, DISCO may necessarily play different roles in the market and change the network configuration, at different hours.

11/02612 How to achieve a 100% RES electricity supply for Portugal?

Krajačić, G. *et al. Applied Energy*, 2011, 88, (2), 508–517.

Portugal is a country with an energy system highly dependent on oil and gas imports. Imports of oil and gas accounted for 85% of the country's requirements in 2005 and 86% in 2006. Meanwhile, the share of renewable energy sources (RES) in the total primary energy consumption was only 14% in 2006. When focusing only on electricity production, the situation is somewhat better. The share of RES in gross electricity production varies between 20% and 35% and is dependent on the hydropower production in wet and dry years. This paper presents, on a national scale, Portugal's energy system planning and technical solutions for achieving 100% RES electricity production. Planning was based on hourly energy balance and use of H_2RES software. The H_2RES model provides the ability to integrate various types of storages into energy systems in order to increase penetration of the intermittent renewable energy sources or to achieve a 100% renewable island, region or country. The paper also represents a stepping-stone for studies offering wider possibilities in matching and satisfying electricity supply in Portugal with potential renewable energy sources. Special attention has been given to intermittent sources such as wind, solar and ocean waves that can be coupled to appropriate energy storage systems charged with surplus amounts of produced electricity. The storage systems also decrease installed power requirements for generating units. Consequently, these storages will assist in avoiding unnecessary rejection of renewable potential and reaching a sufficient security of energy supply.

11/02613 Investment in electricity markets with asymmetric technologies

Genc, T. S. and Thille, T. H. *Energy Economics*, 2011, 33, (3), 379–387.

Capacity investments in electricity markets is one of the main issues in the restructuring process to ensure competition and enhance system security of networks. The authors study competition between hydro and thermal electricity generators under demand uncertainty. Producers compete in quantities and each is constrained: the thermal generator by capacity and the hydro generator by water availability. The authors analyse a two-period game emphasizing the incentives for capacity investments by the thermal generator. The authors characterize both Markov perfect and open-loop equilibria. In the Markov perfect equilibrium, investment is discontinuous in initial capacity and higher than it is in the open-loop equilibrium. However, since there are two distortions in the model, equilibrium investment can be either higher or lower than the efficient investment.

11/02614 Market-clearing for pricing system security based on voltage stability criteria

Kim, M. K. *et al. Energy*, 2011, 36, (2), 1255–1264.

This paper presents a novel technique for representing system security in the operation of decentralized electricity markets, with special emphasis on voltage stability. The market-clearing algorithm is modelled as voltage stability constrained-optimal power flow (VSC-OPF) problem for providing market solutions by means of a function of complying with the required voltage stability criteria. Benders' decomposition is applied for solving the VSC-OPF incorporating post-contingency control actions, which is motivated by the improvement of computational efficiency using parallel processing. The proposed VSC-OPF framework also takes into consideration the bilateral contract information, which is integrated into the market-clearing process and, at the same time, the optimal pricing expressions through computing local marginal prices with respect to ensuring voltage stability are derived. VSC-OPF is tested on the IEEE 14-bus benchmark system and the results obtained, when compared to those obtained by means of a conventional OPF, show that the proposed technique is able to improve system security while yielding better market solutions and total transaction levels.

11/02615 Modeling and prediction of Turkey's electricity consumption using support vector regression

Kavaklioglu, K. *Applied Energy*, 2011, 88, (1), 368–375.

Support vector regression (SVR) methodology is used to model and predict Turkey's electricity consumption. Among various SVR formalisms, ε-SVR method was used since the training pattern set was relatively small. Electricity consumption is modelled as a function of socio-economic indicators such as population, gross national product, imports and exports. In order to facilitate future predictions of electricity consumption, a separate SVR model was created for each of the input variables using their current and past values; and these models were combined to yield consumption prediction values. A grid search for the model parameters was performed to find the best ε-SVR model for each variable based on root mean square error. The electricity consumption of Turkey is predicted until 2026 using data from 1975 to 2006. The results show that electricity consumption can be modelled using support vector regression and the models can be used to predict future electricity consumption.

11/02616 Monthly electricity demand forecasting based on a weighted evolving fuzzy neural network approach

Chang, P.-C. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (1), 17–27.

This research develops a weighted evolving fuzzy neural network for monthly electricity demand forecasting in Taiwan. This study modifies the evolving fuzzy neural network framework (EFuNN framework) by adopting a weighted factor to calculate the importance of each factor among the different rules. In addition, an exponential transfer function ($\exp\ (-D)$) is employed to transfer the distance of any two factors to the value of similarity among different rules, thus a different rule clustering method is developed accordingly. Seven factors identified by the Taiwan Power Company will affect the power consumption in Taiwan. These seven factors will be inputted into the WEFuNN to forecast the electricity demand of the future. The historical data will be used to train the WEFuNN. After training, the trained model will forecast the future electricity demands. Finally, the WEFuNN model is compared with other approaches, which are proposed in the literature. The experimental results reveal that the MAPE for WEFuNN model is 6.43% which is better than the MAPE value for other approaches. Thus, the WEFuNN model is more accurate in forecasting the monthly electricity demand than the other approaches. In summary, the WEFuNN model can be practically applied as an electricity demand forecasting tool in Taiwan.

11/02617 Multi-agent system for energy resource scheduling of integrated microgrids in a distributed system

Logenthiran, T. *et al. Electric Power Systems Research*, 2011, 81, (1), 138–148.

This paper proposes a multi-agent system for energy resource scheduling of an islanded power system with distributed resources, which consists of integrated microgrids and lumped loads. Distributed intelligent multi-agent technology is applied to make the power system more reliable, efficient and capable of exploiting and integrating alternative sources of energy. The algorithm behind the proposed energy resource scheduling has three stages. The first stage is to schedule each microgrid individually to satisfy its internal demand. The next stage involves finding the best possible bids for exporting power to the network and compete in a whole sale energy market. The final stage is to reschedule each microgrid individually to satisfy the total demand, which is the addition of internal demand and the demand from the results of the whole sale energy market simulation. The simulation results of a power system with distributed resources comprising three microgrids and five lumped loads show that the proposed multi-agent system allows efficient management of micro-sources with minimum operational cost. The case studies demonstrate that the system is successfully monitored, controlled and operated by means of the developed multi-agent system.

11/02618 Risk-constrained self-scheduling of a fuel and emission constrained power producer using rolling window procedure

Kazempour, S. J. and Moghaddam, M. P. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (2), 359–368.

This work addresses a relevant methodology for self-scheduling of a price-taker fuel and emission constrained power producer in day-ahead correlated energy, spinning reserve and fuel markets to achieve a trade-off between the expected profit and the risk versus different risk levels based on Markowitz's seminal work in the area of portfolio selection. Here, a set of uncertainties including price forecasting errors and available fuel uncertainty are considered. The latter uncertainty arises because of uncertainties in being called for reserve deployment in the spinning reserve market and availability of power plant. To tackle the price forecasting errors, variances of energy, spinning reserve and fuel prices along with their covariances which are due to markets correlation are taken into account using relevant historical data. In order to tackle available fuel uncertainty, a framework for self-scheduling referred to as rolling window is proposed. This risk-constrained self-scheduling framework is therefore formulated and solved as a mixed-integer non-linear programming problem. Furthermore, numerical results for a case study are discussed.

11/02619 Short-term electricity prices forecasting in a competitive market by a hybrid intelligent approach

Catalão, J. P. S. *et al. Energy Conversion and Management*, 2011, 52, (2), 1061–1065.

In this paper, a hybrid intelligent approach is proposed for short-term electricity prices forecasting in a competitive market. The proposed approach is based on the wavelet transform and a hybrid of neural networks and fuzzy logic. Results from a case study based on the electricity market of mainland Spain are presented. A thorough comparison is carried out, taking into account the results of previous publications. Conclusions are duly drawn.

11/02620 Sustainable electricity generation for rural and peri-urban populations of sub-Saharan Africa: the 'flexy-energy' concept

Azoumah, Y. *et al. Energy Policy*, 2011, 39, (1), 131–141.

Access to energy is known as a key issue for poverty reduction. Electrification rate of sub-Saharan countries is one of the lowest among the developing countries. However, this part of the world has natural energy resources that could help raising its access to energy, then its economic development. An original 'flexy-energy' concept of hybrid solar PV/diesel/biofuel power plant, without battery storage, is performed in this paper. This concept is developed in order to not only make access to energy possible for rural and peri-urban populations in Africa (by reducing the electricity generation cost) but also to make the electricity production sustainable in these areas. For landlocked countries like Burkina Faso, this concept could help them reducing their electricity bill (then their fuel consumption) and accelerate their rural and peri-urban electrification coverage.

11/02621 The potential of demand-side management in energy-intensive industries for electricity markets in Germany

Paulus, M. and Borggrefe, F. *Applied Energy*, 2011, 88, (2), 432–441.

This paper investigates the technical and economic potential of energy-intensive industries to provide demand-side management (DSM) in electricity and balancing markets through 2030. Increasing shares of renewables will lead to a rising demand for ancillary services at the same time that less conventional plants will be available to provide these services. This paper makes projections on the extent to which DSM from industrial processes can provide economic benefits in electricity markets with renewables by providing tertiary reserve capacity. Different industrial processes and their specific technical and economic properties are investigated and compared with other storage devices and electricity generation technologies. Based on an extension of an existing European electricity market model, simulations are used here to make long-term forecasts for market prices, dispatch and investments in the electricity markets through linear optimization.

11/02622 The regional electricity generation mix in Scotland: a portfolio selection approach incorporating marine technologies

Allan, G. *et al. Energy Policy*, 2011, 39, (1), 6–22.

Standalone levelized cost assessments of electricity supply options miss an important contribution that renewable and non-fossil fuel technologies can make to the electricity portfolio: that of reducing the variability of electricity costs, and their potentially damaging impact upon economic activity. Portfolio theory applications to the electricity generation mix have shown that renewable technologies, their costs being largely uncorrelated with non-renewable technologies, can offer such benefits. The authors look at the existing Scottish generation mix and examine drivers of changes out to 2020. The authors assess recent scenarios for the Scottish generation mix in 2020 against mean-variance efficient portfolios of electricity-generating technologies. Each of the scenarios studied implies a portfolio cost of electricity that is between 22% and 38% higher than the portfolio cost of electricity in 2007. These scenarios prove to be mean-variance ‘inefficient’ in the sense that, for example, lower variance portfolios can be obtained without increasing portfolio costs, typically by expanding the share of renewables. As part of extensive sensitivity analysis, the authors find that wave and tidal technologies can contribute to lower risk electricity portfolios, while not increasing portfolio cost.

11/02623 Using the decentralized and liberalized electricity market microworld (LEMM) as an educational tool

Paşaoğlu, G. *Energy Policy*, 2011, 39, (1), 187–199.

Decentralized and liberalized electricity market involves a great deal of interdisciplinary concepts, including economic, commercial, environmental and technological issues. Consequently, the system is complicated. Accordingly, nowadays introductory courses focusing on the electricity market dynamics have been added to the curriculum at many universities. However, as the electricity market dynamics are complicated, it is not straightforward for students to understand. A teaching tool to assist students to better understand strategic behaviours in the market is thus in high demand. Due to these reasons, liberalized electricity market microworld (LEMM), incorporating a system dynamics based simulation model, is developed. The LEMM's contribution to the students learning and understanding of the decentralized and liberalized electricity market dynamics have been explored by organizing game sessions with the LEMM for 49 students who participated in the energy policy and planning course at Bogazici University. The findings obtained from the exploratory study reveal that the students improved their understanding of the liberalized and decentralized electricity market through the game session with the LEMM. In this paper, the general characteristics of the LEMM and the underlying model are presented, the microworlds', particularly the LEMM's potential contribution to learning and teaching is discussed.

07 STEAM RAISING

Boiler operation/design

11/02624 A 7 year long measurement period investigating the correlation of corrosion, deposit and fuel in a biomass fired circulated fluidized bed boiler

Sandberg, J. *et al. Applied Energy*, 2011, 88, (1), 99–110.

The present investigation involves a unique, 7-year-long (2001–2007) study of corrosion and deposits on superheater tubes in a biomass-fired circulated fluidized bed boiler. These measurements are correlated against the different fuels used over this period. In the earlier years, the boiler was run with a mixture of different biomass fuels and peat. In later years, recycled wood was introduced into the fuel mix. The deposit growth rate approximately doubled when the recycled wood content of the fuel was increased to 10–20%. Small amounts of chlorine and zinc were found both in the recycled wood and in the deposit layer. These elements together with alkali metals from the biomass, have the potential to form sticky compounds that increase the deposit growth rate. The corrosion rate of the superheater tubes varied over the study period. A number of possible explanations for this phenomenon are discussed.

11/02625 Exergy analysis of a steam production and distribution system including alternatives to throttling and the single pressure steam production

Rian, A. B. and Ertesvåg, I. S. *Energy Conversion and Management*, 2011, 52, (1), 703–712.

The operative steam production and distribution system of Kårstø natural gas processing plant at four operating conditions was studied by exergy analysis. The eight boilers, of which two are direct fired produce steam at a single pressure. The steam (at 59 bar, 420 °C) is then distributed by extensive use of throttling. Most of the steam is utilized at low pressure (7 bar, 200 °C). The effect of implementing steam turbines in steam distribution system, increase of steam production pressure (from 59 to 120 bar) or two-stage pressure steam production (120/59 bar) were examined. The exergy efficiency of the existing system was 44.3%. Implementing steam turbines or elevation of production pressure (single/dual) resulted in marginal exergy efficiencies of 92%, 89.8% and 98.7%, respectively. Combinations of steam turbines and elevated pressure gave a ratio of 90.9%. In terms of lower heating value, the marginal electric efficiencies ranged from 89% to 104%. The single most fuel exergy demanding alternative was the elevated pressure, with 3.6% increase, which resulted in 18.5 MW of extra electric power. The corresponding figures for steam turbines and two-stage pressure were 3.0%/16.2 MW and 2.6%/15.6 MW. Thus, the study provided an example from an existing, industrial steam system that illustrates both the losses in throttling and low-pressure steam production, and the practical potentials for improvement.

11/02626 Internal steam reforming in solid oxide fuel cells: status and opportunities of kinetic studies and their impact on modelling

Mogensen, D. *et al. Journal of Power Sources*, 2011, 196, (1), 25–38.

Solid oxide fuel cells (SOFC) systems with internal steam reforming have the potential to become an economically competitive technology for cogeneration power plants, exploiting its significantly higher electrical efficiency compared to existing technologies. Optimal design and operation of such a system require SOFC models that include accurate description of the steam reforming rate. The objective of this article is to review the reported kinetic expressions for the steam reforming reaction. Extensive work has been performed on traditional catalysts for steam reforming. Because of differences in operating conditions, catalyst support material and structure it is critical to transfer this knowledge directly to internal reforming in SOFCs, which is discussed in further detail in this article. There are big differences in the reported kinetic expression for steam reforming over both industrial Ni catalysts and SOFC anode materials. Surprisingly, there is a good agreement between measured rates proportional to geometric anode area at high operating temperatures, even for very different anodes. Detailed experimental data on the intrinsic steam reforming kinetics of Ni-YSZ are necessary for micro structure SOFC modelling, such expression are however lacking, but it may be viable to use measurements on industrial steam reforming catalysts instead. Nevertheless there is a further need for experimental studies on determining the exact steam reforming kinetics for SOFC anodes.

11/02627 Prediction of performance, energy savings and increase in profitability of two gas turbine steam generator cogeneration plant, based on experimental data

Aguilar, F. J.-E. *et al. Energy*, 2011, 36, (2), 742–754.

This study analyses three feasible regulation methods of an in-service cogeneration plant. The main task is to study the potential energy savings, CO_2 reduction and the increase in profitability compatible with the lowest transformation costs. The cogeneration system is composed of two General Electric LM2500 gas turbines and a heat recovery steam generator (HRSG). Two plant localizations in Spain have been considered; San Fernando (Cádiz) where the current plant is located, and Burgos. The latter has been taken into account to analyse the effect of cooler weather on the regulation methods. The paper has been divided into three parts. First, a revision of the current legislation regarding cogeneration in Spain is shown. Second, a description of the power plant and the proposed regulation methods are set out. Then, the cogeneration plant is modelled with the objective of evaluating the effects of the regulation methods in power, generated steam and thermal oil flow. Finally, the model was applied to analyse the profit obtained from different regulation combinations and to compare the benefits of those regulation methods in the two locations with different climatic situations. The main conclusion reached is the importance to meet the requirements of Spanish legislation in order to obtain advantages in the sale of electricity; an increased profit of up to 60% was obtained in the simulation. In addition, it is evident that the regulation is more important when ambient temperature is lower.

11/02628 Software system ‘DIORES’ for the operation diagnosis of a steam power plant unit

Savić, B. M. and Jovanović, R. Ž. *Energy*, 2011, 36, (2), 1187–1195.

Despite the long operating experience with steam power units in the electric power system of Serbia (out of which some are at the end of or had even passed their planned working lives), unfortunately, there is a lack of data for their operating regimes, process parameters and performance deviations, the economy and operating states for the previous period. These data would not only be useful for optimal process control, but also for the planning of maintenance, retrofits and repowering of power plants. For these and other equally important reasons, the software system for the diagnosis of operating conditions, control of economy and operating states of different components has been developed for the referential steam power unit. A better control of the process and operating state, thanks to the use of the results obtained with this software system, will bring a lasting benefit to the efficiency and economy increase. Furthermore, it will enable an increase of reliability and availability of steam turbine units and make their working life longer. The basic characteristics of this software system and some of the results obtained by its testing using the available data base for referential unit operation are presented in this paper.

11/02629 Techniques for processing remote field eddy current signals from bend regions of steam generator tubes of prototype fast breeder reactor

Thirunavukkarasu, S. *et al. Annals of Nuclear Energy*, 2011, 38, (4), 817–824.

Steam generator (SG) is one of the most critical components of sodium cooled fast breeder reactor. Remote field eddy current (RFEC) technique has been chosen for in-service inspection (ISI) of these ferromagnetic SG tubes made of modified 9Cr–1Mo steel (Grade 91). Expansion bends are provided in the SGs to accommodate differential thermal expansion. During ISI using RFEC technique, in expansion bend regions, exciter–receiver coil misalignment, bending stresses, probe wobble and magnetic permeability variations produce disturbing noise hindering detection of defects. Fourier filtering, cross-correlation and wavelet transform techniques have been studied for noise reduction as well as enhancement of RFEC signals of defects in bend regions, having machined grooves and localized defects. Performance of these three techniques has been compared using signal-to-noise ratio (SNR). Fourier filtering technique has shown better performance for noise reduction while cross-correlation technique has resulted in significant enhancement of signals. Wavelet transform technique has shown the combined capability of noise reduction and signal enhancement and resulted in unambiguous detection of 10% of wall loss grooves and localized defects in the bend regions with SNR better than 7 dB.

08 COMBUSTION

Burners, combustion systems

11/02630 A comparison of the thermal, emission and heat transfer characteristics of swirl-stabilized premixed and inverse diffusion flames

Zhen, H. S. *et al. Energy Conversion and Management*, 2011, 52, (2), 1263–1271.

Two swirl-stabilized flames, a premixed flame (PMF-s) and an inverse diffusion flame (IDF-s), were investigated experimentally in order to obtain information on their thermal, emission and heat transfer characteristics. The two flames, having different global air/fuel mixing mechanisms, were compared under identical air and fuel flow rates. Results showed that the two flames have similar visual features such as flame shape, size and structure because the Reynolds number and the swirl number which are important parameters representative of the aerodynamic characteristics of a swirling jet flow, are almost the same for the two flames. The minor dissimilarity in flame colour and flame length indicates that the IDF-s is more diffusional. Both the PMF-s and IDF-s are stabilized by the internal recirculation zone (IRZ) and the IDF-s is more stable. Flame temperature is uniformly distributed in the IRZ due to the strong mixing caused by flow recirculation. The highest flame temperature is achieved at the main reaction zone and it is higher for the PMF-s due to more rapid and localized heat release. For the IDF-s, the thermal NO mechanism dominates the NO_x formation. For the PMF-s, both the thermal and prompt mechanisms tend to play important roles in the global NO_x emission under rich conditions. The comparison of $EINO_x$ and EICO shows that the PMF-s has lower level of NO_x emission under lean combustion and lower level of CO emission under all conditions. The reason is that the air/fuel premixing in the PMF-s significantly enhances the mixedness of the supplied air/fuel mixture. The analysis of the behaviours of the impinging PMF-s and IDF-s heat transfer reveals that because the PMF-s has more rapid and localized heat release at the main reaction zone, the peak heat flux is higher than that of the IDF-s and the IDF-s has more uniform heating effect. A comparison of the overall heat transfer rates shows that, due to more complete combustion, the PMF-s has higher overall heat transfer.

11/02631 A novel soot model for fires: validation in a laminar non-premixed flame

Beji, T. *et al. Combustion and Flame*, 2011, 158, (2), 281–290.

A soot formation and oxidation model is presented for laminar axisymmetric non-premixed flames using a mixture fraction based combustion model, which is appropriate for fires where the detailed chemistry of the fuels is unknown. This model relies on an analytical description of soot processes in the centreline of the flame guided by flow similarity relationships established from global experimental data in smoke point laminar flames. The selection of the model parameters is based on numerical calibrations by comparison with detailed temperature and soot concentrations in laminar candle type flames. Application to any fuel is made by accounting only for the sooting tendency employing the laminar smoke point height of the fuel. It is shown that the soot formation and oxidation model gives satisfactory results and a good phenomenological explanation of the influence of soot processes on the structure of the flame.

11/02632 A study on municipal solid waste (MSW) combustion in N_2/O_2 and CO_2/O_2 atmosphere from the perspective of TGA

Lai, Z. *et al. Energy*, 2011, 36, (2), 819–824.

In this paper, the combustion behaviour of municipal solid waste (MSW) is carried out in a thermogravimetric analyser (TGA) under different N_2/O_2 and CO_2/O_2 atmospheres with temperature ranging from 100 to 1000 °C. TG (thermogravimetric) and DTG (derivative thermogravimetric) curves are analysed. The *n*th order reaction fitting model is used to yield the activation energy of reduction process according to the degree of conversion. The results indicate that all samples lose most their weight between 200 and 540 °C. As the oxygen concentration increased, conversion rate curves and DTG curves shift to lower temperature without significant change in its shape. At the same oxygen concentration, the peak values in CO_2/O_2 atmosphere are smaller than those in N_2/O_2 atmosphere, indicating that CO_2 has a higher inhibitory effect than N_2 on MSW combustion. After 600 °C, the weight loss peak appears much later in CO_2/O_2 atmosphere than it does in N_2/O_2 atmosphere. With the increase of heating rate, the maximum weight loss rates of samples increase obviously. The three-step reaction of *n*th order reaction model fits the weight loss very well.

11/02633 Combustion of coal–water suspensions

Kijo-Kleczkowska, A. *Fuel*, 2011, 90, (2), 865–877.

Combustion technologies using coal–water suspensions create a number of new possibilities for organising combustion processes so that they fulfil contemporary requirements (e.g. in terms of the environment protection-related issues). Therefore, an in-depth analysis is necessary for examining the technical applications of coal in the form of a suspension as a fuel. The paper undertakes the complex study of coal–water suspension combustion in air and in the fluidised beds. This, according to the author, best simulates the conditions that should be satisfied in order to use the new 'fuel' efficiently and ecologically. An important element of the study was the identification of coal–water suspension drops, its complex morphology and evolution in the combustion process. The mathematical model enables the prognosis for change of the surface and the centre temperatures and a mass loss of the coal–water suspension during combustion in air and in the fluidised bed.

11/02634 Decomposition and gasification of pyrolysis volatiles from pine wood through a bed of hot char

Sun, Q. *et al. Fuel*, 2011, 90, (3), 1041–1048.

Pine wood was pyrolysed in a fixed bed reactor at a heating rate of 10 °C and a final temperature of 700 °C, and the resultant volatiles were allowed to be secondarily cracked through a tubular reactor in a temperature range of 500–700 °C with and without packing a bed of char. The thermal effect and the catalytic effect of char on the cracking of tar were investigated. An attempt was made to deconvolute the intermingled contributions of the char-catalysed tar cracking and the char gasification to the yields of gaseous and liquid products. It was found that the wood char (charcoal) was catalytically active for the tar cracking at 500–600 °C, while at 650–700 °C, the thermal effect became a dominant mode of the tar cracking. Above 600 °C, the autogenerated steam gasified the charcoal, resulting in a marked increase in the yield of gaseous product and a significant change in the gas composition. An anthracite char (A-char), a bituminous coal char (B-char), a lignite char (L-char) and graphite also behaved with catalytic activities towards the tar cracking at lower temperature, but only L-char showed reactivity for gasification at higher temperature.

11/02635 Effect of kaolin addition on ash characteristics of palm empty fruit bunch (EFB) upon combustion

Konsomboon, S. *et al. Applied Energy*, 2011, 88, (1), 298–305.

Palm empty fruit bunch (EFB), a by-product of the palm oil industry, is being recognized as one of the most potential kinds of biomass for energy production in Thailand. However, it has been reported that, in combusting EFB in boilers, some compounds evolving from abundant alkali metals in EFB into gas-phase condense and deposit on low-temperature surfaces of heat exchange equipment, causing fouling and corrosion problems. To come up with a solution to impede the deposition, kaolin, which is abundant in kaolinite ($Al_2Si_2O_5\ (OH)_4$), is employed to capture the alkali metal vapours eluding from the combustion region. The experiments were designed to simulate the combustion situations that may take place when kaolin is utilized in two different approaches: premixing of kaolin with EFB prior to combustion and gas-phase reaction of volatiles from EFB with kaolin. The amounts of kaolin used were 8% and 16% by weight based on dry weight of EFB, which were equivalent to one and two times of the theoretical kaolin requirement to capture all potassium originally present in the EFB. The furnace temperatures used for EFB combustion were 700–900 °C and ashes were analysed by XRF and XRD. The results revealed that, under the kaolin premixing condition, 8% kaolin addition was sufficient to capture the potassium compounds at low temperature, i.e. 700 and 800 °C. However, when the temperature was increased to 900 °C, 16% kaolin addition was needed to completely capture the potassium compounds. The results from gas-phase experiments showed that kaolin can capture volatile potassium at maximum 25% at 900 °C. The XRD results showed, for both experimental cases, the evidence of formation of the high melting temperature potassium-alumino-silicates, which confirmed the reaction of potassium compounds with kaolin. The study also suggests that the premixing method is better than the other because of its higher overall capture efficiency.

11/02636 Efficiency analysis of radiative slab heating in a walking-beam-type reheating furnace

Han, S. H. *et al. Energy*, 2011, 36, (2), 1265–1272.

The thermal efficiency of a reheating furnace was predicted by considering radiative heat transfer to the slabs and the furnace wall. The entire furnace was divided into 14 sub-zones, and each sub-zone was assumed to be homogeneous in temperature distribution with one medium temperature and wall temperature, which were computed on the basis of the overall heat balance for all of the sub-zones. The thermal energy inflow, thermal energy outflow, heat generation by fuel combustion, heat loss by the skid system, and heat loss by radiation through the boundary of each sub-zone were considered to give the two temperatures of each sub-zone. The radiative heat transfer was solved by the FVM radiation method, and a blocked-off procedure was applied to the treatment of the slabs. The temperature field of a slab was calculated by solving the transient heat conduction equation with the boundary condition of impinging radiation heat flux from the hot combustion gas and furnace wall. Additionally, the slab heating characteristics and thermal behaviour of the furnace were analysed for various fuel feed conditions.

11/02637 Estimating soot volume fraction and temperature in flames using stochastic particle swarm optimization algorithm

Sun, Y.-P. *et al. International Journal of Heat and Mass Transfer*, 2011, 54, (1–3), 217–224.

A simulation investigation for simultaneous reconstruction of distributions of temperature and soot volume fraction from multi-wavelength emission in a sooting flame using the stochastic particle swarm optimizer (PSO) algorithm is presented. The self-absorption of the flame is considered. The selection of parameters of the stochastic PSO algorithm and detection wavelengths is analysed. The effects of measurement errors and optical thickness of the flame on the accuracy of the reconstruction are investigated. It proved that the stochastic PSO algorithm is robust and can obtain accurate distributions of temperature and soot volume fraction from line-of-sight intensities in only several wavelengths, especially in the flame with large optical thickness, while other methods neglecting self-attenuation of the flame will take some errors.

11/02638 Ethanol flame synthesis of highly transparent carbon thin films

Li, Z. *et al. Carbon*, 2011, 49, (1), 237–241.

Large area (the order of centimetres), flexible thin films of amorphous carbon were prepared on copper foils by an ethanol flame synthesis method. The carbon films exhibit high transmittance in the visible and near infrared range (up to 90% at 550 nm). Schottky diodes formed by combining the carbon films with n-type silicon wafers show high on/off ratio (up to 150) photocurrents at air-mass 1.5 and illumination intensity of 100 mW/cm^2.

11/02639 Experimental investigation on simultaneous measurement of temperature distributions and radiative properties in an oil-fired tunnel furnace by radiation analysis

Lou, C. *et al. International Journal of Heat and Mass Transfer*, 2011, 54, (1–3), 1–8.

The paper reports experimental investigations on simultaneous measurement of temperature distribution and radiative properties in an oil-fired tunnel furnace by radiation analysis. Two colour CCD cameras were used to obtain visible thermal radiation in the furnace. A radiation imaging model was established by the calculation of radiative transfer equation in the furnace. The temperature distribution and radiative properties can be obtained from the inversion of the radiative imaging model. The validity of radiative imaging model was verified by the numerical analysis of cavity radiation and isothermal system radiation, and the accuracy of reconstruction method was validated by simulation reconstruction. The experimental analysis was divided into two parts. First, the temperatures of wall surface were calculated from the radiative image of refractory wall and compared with the measured temperature of a thermocouple. The difference between the two methods was only about 20 K. Secondly, the temperature distributions in the furnace, absorption coefficients of combustion medium, and emissivities of refractory wall were reconstructed. Because of a single burner in the tunnel furnace, the temperature distributions in the XY vertical sections in the furnace were with temperature higher in the centre and lower near the refractory wall surface, and the temperatures decreased along the length of the tunnel furnace. The measured emissivity of refractory wall showed that the refractory material of RPA-MC30 is with high reflectivity in visible spectrum.

11/02640 Experimental study of a plat-flame micro combustor burning DME for thermoelectric power generation

Jiang, L. Q. *et al. Energy Conversion and Management*, 2011, 52, (1), 596–602.

A centimetre magnitude thermoelectric (TE) power generation system based on a plat-flame micro combustor burning dimethyl ether (DME) has been developed. The chamber wall of this micro combustor was made of two parallel sintered porous plates which acted as mixture inlet. The main virtue of this combustor is that it can keep combustor wall at lower temperature for reducing heat loss when sustaining a stable flame. Experimental test results showed it was feasible to obtain stable DME/air premixed flame at lean combustion situations in the micro combustor. The combustion load of this 0.48 cm^3 chamber capacity was 20–200 W at equivalence ratio $\Phi = 0.6$. Though the flame temperature was above 1000 °C, the combustor's wall temperature was near 600 °C lower than flame temperature. In the demonstrated TE power generation system which integrated the plat-flame micro combustor, a heat spreader had good effect on uniforming the hot side temperature field of TE modules. Cooled by water and with 150 W input power at $\Phi = 0.7$, the system produced 10 V output at open circuit and 4 V at 10 Ω load. The maximum power output was above 2 W, and the maximum overall chemical-electric energy conversion efficiency was 1.25%.

11/02641 Experimental study of wet flue gas desulphurization with a novel type PCF device

Gao, H. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (2), 189–195.

Scrubbers are being widely used to remove the dust, sulfur dioxide and other harmful gases from coal-fired boilers. In this paper, a novel 'wet-type' desulfurization absorber, the PCF device (Chinese LOGO), was developed and studied through an experimental method. The mixture of air and SO_2 was used as simulated flue gas and $CaCO_3$-in-water suspension was used as absorbent. The results show that the PCF device has a good overall performance for FGD. Under the moderate conditions employed, the content of SO_2 in outlet flue gas can achieve a level much lower than that permitted, while the pressure drop is very small due to co-flows in preliminarily treating chamber and no venturi structure in inlet tube. Guide plates and self-excitation chamber can improve the SO_2 removal efficiency by intensifying the mass-transfer and second purification. Some feasible process parameters are as follows: slurry pH value = 5.6–6.0, liquid–gas ratio = 8.7–10.4 L/m^3, superficial gas velocity in inner cylinder = 3.5–4.5 m/s, and addition of Cl^- (in the form of $CaCl_2$) to the slurry (25 g/L) decreased the degree of SO_2 removal about 13.12%.

11/02642 Fuel effects on flame lift-off under diesel conditions

Persson, H. *et al. Combustion and Flame*, 2011, 158, (1), 91–97.

An apparent relation between the lift-off length under diesel conditions and the ignition quality of a fuel has previously been reported. To cast light on the underlying mechanism, the current study aims to separate flame lift-off effects of the chemical ignition delay from those of other fuel properties under diesel conditions. Flame lift-off was measured in an optical diesel engine by high-speed video imaging of OH-chemiluminescence. Fuel and ambient-gas properties were varied during the experiment. Only a weak correlation was found between ignition delay and lift-off length. The data indicate that this correlation is due to a common, stronger correlation with the ambient oxygen concentration. The chemical ignition delay and the fuel type had similar, weak effects on the lift-off length. A recently proposed mechanism for lift-off stabilization was used to interpret the results. It assumes that reactants approaching the lift-off position of the jet are mixed with high-temperature products found along the edges of the flame, which trigger autoignition. In this picture, the fuel effect is most likely due to differences in the amount of mixing with high-temperature products that is required for autoignition. In the current experiment, all lift-off effects seem to arise from variations in the reactant and product temperatures, induced by fuel and ambient properties.

11/02643 Gas/particle flow and combustion characteristics and NO$_x$ emissions of a new swirl coal burner

Chen, Z. *et al. Energy*, 2011, 36, (2), 709–723.

Due to the limits of reserves and price for high-rank coal, the low-rank coal has been employed as fuel for power generation in China and will be eventually employed in the world. To burn low-rank coal, centrally fuel-rich swirl coal combustion burner has been studied in Harbin Institute of Technology. This paper reviews and analyses the major research results. The work has included both experiments and numerical simulation. The experiments were conducted using small-scale single-phase experimental equipment, a gas/particle two-phase test facility and 200- and 300-MW$_e$ wall-fired utility boilers. For the burner, the primary air and glass beads partially penetrate the central recirculation zone and are then deflected radially. At the centre of the central recirculation zone, there is high particle volume flux and large particle size. For the burners the local mean CO concentrations, gas temperatures and temperature gradient are higher, and the mean concentrations of O$_2$ and NO$_x$ in the jet flow direction in the burner region are lower. Moreover, the mean O$_2$ concentration is higher and the gas temperature and mean CO concentration are lower in the side wall region. Centrally fuel-rich burners have been successfully used in 200- and 300-MWe wall-fired pulverized coal utility boilers.

11/02644 Influence of primary air ratio on flow and combustion characteristics and NO$_x$ emissions of a new swirl coal burner

Jing, J. *et al. Energy*, 2011, 36, (2), 1206–1213.

Cold airflow experiments on a small-scale burner model, as well as *in situ* experiments on a centrally fuel-rich swirl coal combustion burner were conducted. Measurements were taken from within a 300 MW$_e$ wall-fired pulverized-coal utility boiler installed with eight of centrally fuel-rich swirl coal combustion burners in the bottom row of the furnace during experiments. Various primary air ratios, flow characteristics, gas temperature and gas species concentrations in the burner region were measured. The results of these analyses show that with decreasing primary air ratio, the swirl intensity of air, divergence angles and maximum length and diameter of the central recirculation zone all increased, and the turbulence intensity of the jet flow peaked but decayed quickly. In the burner nozzle region, gas temperature, temperature gradient and CO concentration increased with decreasing primary air ratio, while O$_2$ and NO$_x$ concentration decreased. Different primary air ratios, the gas temperatures and gas species concentrations in the side-wall region varied slightly.

11/02645 Laminar flame speeds and extinction limits of conventional and alternative jet fuels

Kumar, K. *et al. Fuel*, 2011, 90, (3), 1004–1011.

Experimental results of laminar flame speeds and extinction stretch rates for the conventional (Jet-A) and alternative (S-8) jet fuels are acquired and compared to the results from earlier studies for neat hydrocarbon surrogate components, including *n*-decane and *n*-dodecane. Specifically, atmospheric pressure laminar flame speeds are measured using a counterflow twin-flame configuration for Jet-A/O$_2$/N$_2$ and S-8/O$_2$/N$_2$ mixtures at preheat temperatures of 400, 450, and 470 K and equivalence ratios ranging from 0.7 to 1.4. The flow field is recorded using digital particle image velocimetry. Linear extrapolation is then applied to determine the unstretched laminar flame speed. Experimental data for the extinction stretch rates of the nitrogen diluted jet fuel/oxidizer mixtures as a function of equivalence ratio are also obtained. In addition, the experimental data of Jet-A are compared to the computed values using a chemical kinetic mechanism for a kerosene surrogate reported in literature. A sensitivity analysis is further performed to identify the key reactions affecting the laminar flame speed and extinction stretch rate for this kerosene surrogate.

11/02646 Modelling of mass loss of char particles during combustion in flow of inert material

Pelka, P. *Fuel*, 2011, 90, (3), 932–940.

The inspiration for this research was an attempt at the numerical simulation of the process of mass loss of char particles during its combustion in the upper zone of a CFB boiler furnace. In the first part of the research an experiment was carried out, during which singular char particles were burned in a flow of heated sand. During the course of this test manually polished spherical particles chosen from arbitrary real coal particles were used whose diameter amounted to 10 mm. The mass loss of burning particles was recorded with a tensometric branch scale. The measuring equipment applied enabled the observation of the mass loss both as a result of combustion and erosion resulting from the contact of inert material accelerated particles with the upper surface of the motionless particle being tested. The results of the experiment were compared with the results of numerical simulation, where for the first time the mass loss of a coal particle was presented as the superposition of two separate processes, i.e. combustion and surface erosion. The values obtained indicated a good level of conformity which may illustrate the possibility of applying this model in real conditions.

11/02647 Physical and chemical comparison of soot in hydrocarbon and biodiesel fuel diffusion flames: a study of model and commercial fuels

Maricq, M. M. *Combustion and Flame*, 2011, 158, (1), 105–116.

Data are presented to compare soot formation in both surrogate and practical fatty acid methyl ester biodiesel and petroleum fuel diffusion flames. The approach here uses differential mobility analysis to follow the size distributions and electrical charge of soot particles as they evolve in the flame, and laser ablation particle mass spectrometry to elucidate their composition. Qualitatively, these soot properties exhibit a remarkably similar development along the flames. The size distributions begin as a single mode of precursor nanoparticles, evolve through a bimodal phase marking the onset of aggregate formation, and end in a self preserving mode of fractal-like particles. Both biodiesel and hydrocarbon fuels yield a common soot composition dominated by $C_xH_y^+$ ions, stabilomer PAHs, and fullerenes in the positive ion mass spectrum, and C_x^- and $C_{2x}H^-$ in the negative ion spectrum. These ion intensities initially grow with height in the diffusion flames, but then decline during later stages, consistent with soot carbonization. There are important quantitative differences between fuels. The surrogate biodiesel fuel methyl butanoate substantially reduces soot levels, but soot formation and evolution in this flame are delayed relative to both soy and petroleum fuels. In contrast, soots from soy and hexadecane flames exhibit nearly quantitative agreement in their size distribution and composition profiles with height, suggesting similar soot precursor chemistry.

11/02648 Predictive analysis of combined burner parameter effects on oxy-fuel flames

Boushaki, T. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 202–212.

The present paper aims at studying the influence of burner parameters with a separated-jet configuration, namely nozzles diameters and separation distance between the jets, on the flame characteristics (lift-off positions of flame and flame length). The experimental layout considers the use of OH-chemiluminescence to measure the flame characteristics for different combinations of processing conditions. The predictive analysis is based on a neural computation that considers the correlations between the inputs and the outputs of a combustion system using a configuration of separated jet. The predictive analysis shows that a good agreement is found between numerical and experimental results in the case where the predictions are within the process window. The exploration of other process parameter combinations beyond that window gives less convincing results. This is mainly attributed to the fact that steady state characteristics are predicted numerically whereas it is expected experimentally that some of the burner parameter combinations can lead to an increase of the parameters characterizing the flame.

11/02649 Pyrolysis of grape bagasse: effect of pyrolysis conditions on the product yields and characterization of the liquid product

Demiral , I. and Ayan, E. A. *Bioresource Technology*, 2011, 102, (4), 3946–3951.

In this study, pyrolysis of grape bagasse was investigated with the aim to study the product distribution and their chemical compositions and to identify optimum process conditions for maximizing the bio-oil yield. Particular investigated process variables were temperature (350–600 °C), heating rate (10–50 °C/min) and nitrogen gas flow rate (50–200 cm^3/min). The maximum oil yield of 27.60% was obtained at the final pyrolysis temperature of 550 °C, sweeping gas flow rate of 100 cm^3/min and heating rate of 50 °C/min in a fixed-bed reactor. The elemental analysis and heating value of the bio-oils were determined, and then the chemical composition of the bio-oil was investigated using chromatographic and spectroscopic techniques such as column chromatography, ^{1}H NMR and FTIR. The fuel properties of the bio-oil such as flash point, viscosity and density were also determined. The bio-oils obtained from grape bagasse were presented as an environmentally friendly feedstock candidate for bio-fuels.

11/02650 Thermo-mechanical life prediction for material lifetime improvement of an internal cooling system in a combustion liner

Kim, K. M. *et al. Energy*, 2011, 36, (2), 942–949.

This paper is concerned with heat transfer analysis and life prediction in the after shell section of a gas turbine combustion liner with internal cooling passage. The method in the present study is the process to design cooling systems which enhance the material lifetime as well as the cooling performance. Using this method, the major causes of lifetime-affecting thermal damage induced by heat transfer distributions were found in the internal cooling system of the after shell section. From startup to shutdown, high thermal deformation occurred between the hot and coolant side walls in the welding region, the nearby cooling hole, and above the divider of the C-channel. Three regions were therefore very weak in relation to the thermal cycle. Moreover, these locations were in close agreement with the locations of thermal cracks in an actual gas turbine combustor currently in service.

11/02651 Three-dimensional modelling of in-furnace coal/coke combustion in a blast furnace

Shen, Y. S. *et al. Fuel*, 2011, 90, (2), 728–738.

A three-dimensional mathematical model of the combustion of pulverized coal and coke is developed. The model is applied to the region of lance-blowpipe-tuyere-raceway-coke bed to simulate in-furnace phenomena of pulverized coal injection in an ironmaking blast furnace. The model integrates not only pulverized coal combustion model in the blowpipe-tuyere-raceway-coke bed but also coke combustion model in the coke bed. The model is validated against the measurements under different conditions. The comprehensive in-furnace phenomena are investigated in the raceway and coke bed, in terms of flow, temperature, gas composition, and coal burning characteristics. The underlying mechanisms for the in-furnace phenomena are also analysed. The simulation results indicate that it is important to include recirculation region in the raceway and the coke bed reactions for better understanding in-furnace phenomena. The model provides a cost-effective tool for understanding and optimizing the in-furnace flow-thermo-chemical characteristics of the PCI operation in full-scale blast furnaces.

Fire safety

11/02652 Assessment of the shape of vertical jet fires

Palacios, A. and Casal, J. *Fuel*, 2011, 90, (2), 824–833.

Experiments were carried out on relatively large vertical propane sonic and subsonic exit velocity jet fires (up to approximately 10 m in length and 1.5 m in width). The main geometrical features of jet fires (flame shape, length and width) were determined by analysing infrared images. From the observations of visible and infrared images, the flame boundary was defined as that corresponding to a temperature of 800 K. Results were compared with the shapes proposed in previous research projects. In the present study, data for sonic and subsonic exit velocity flames indicated that a cylindrical shape could accurately describe the shape of a vertical propane jet fire in still air. The length of such a cylindrical jet fire was the radiant flame length and the equivalent diameter was that corresponding to a volume equal to that surrounded by the aforementioned boundary. The ratio of flame length to diameter was found to be 7. Expressions are proposed to predict the values of jet flame length and width as a function of orifice exit diameter and Reynolds number.

11/02653 Comparison of the distribution of carbon monoxide concentration and temperature rise in channel fires: reduced-scale experiments

Yang, D. *et al. Applied Thermal Engineering*, 2011, 31, (4), 528–536.

In a channel fire, the transports of the two primary hazards, heat and CO species, are dominated by different mechanisms. Experiments were conducted in a horizontal channel with dimensions of 66.0 m long × 1.5 m wide × 1.3 m high to investigate the spatial distributions of CO volume concentration and those of temperature rise. The effects of longitudinal ventilation were also considered. Both in the longitudinal direction and in the vertical direction, profiles of CO volume concentration differ with those of temperature rise. In the downstream direction, the temperature rise of smoke flow decays rapidly with increase in the distance from the fire origin, while CO volume concentration remains constant in the longitudinal direction. A larger longitudinal ventilation velocity leads to a slower decay in temperature rise along the longitudinal direction. However, longitudinal ventilation has a small influence on the longitudinal profiles of normalized CO volume concentration. As compared with temperature rise, the CO volume concentration decays more slowly with the decrease in height under the conditions without longitudinal ventilation. However, a relatively large longitudinal ventilation velocity leads to a high similarity between the vertical profile of CO volume concentration and that of temperature rise.

11/02654 Estimation of lower flammability limits in high-pressure systems. Application to the direct synthesis of hydrogen peroxide using supercritical and near-critical CO_2 and air as diluents

Piqueras, C. M. *et al. The Journal of Supercritical Fluids*, 2011, 56, (1), 33–40.

A method for the prediction of the lower flammability limit at high pressures, where data are scarce, based on the calculation of adiabatic flame temperatures for the mixtures $H_2 + O_2$ in CO_2 and N_2, between 1.0 and 300 bar and 288–348 K is presented. A group contribution equation of state (GC-EoS) has been selected to predict thermodynamic properties of the mixture, i.e. residual enthalpy, heat capacity and others, as well as phase equilibrium data, giving deviations lower than 10% at high pressures. The use of CO_2 as a diluent increases the operational margin from 4.5 mol% H_2 at 1 bar up to about 7.0–9.0 mol% H_2 at 200 bar due to the increase in the heat capacity. On the other hand, the use of nitrogen or air as a diluent only increases the margin from 5.2 mol% H_2 at 1 bar up to about 6.0 mol% H_2 at 200 bar.

11/02655 Explosion hazards related to hydrogen releases in nuclear facilities

Taveau, J. *Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 8–18.

Hydrogen explosion risk needs to be carefully assessed and evaluated in nuclear facilities because of the potential catastrophic consequences: breakdown of safety equipments, failure of containment, dissemination of radioactive materials in the environment. When studying an indoor release, one possible simplification is to assume a perfect gas mixing inside the room. This assumption is effectively often used to evaluate toxic risks in the environment outside a building. However, perfect gas mixing assumption is only a rough approximation, as indoor concentrations can largely differ from mean values, due to buoyancy, recirculation zones or obstacles for example. In order to better evaluate the risk of explosion in case of an accidental release of hydrogen, IRSN conducted a numerical study using FLACS CFD software. Several parameters have been studied to identify dangerous situations and draw a representative picture of the risk: room size, position and direction of hydrogen leak, ventilation characteristics. Hydrogen release flow rates used for numerical simulations have been chosen as the highest leak rate which, by applying the assumption of perfect mixing, produces an average concentration in the room equal to hydrogen lower flammability limit (LFL). Simulation results indicate that in some particular configurations, especially for impinging hydrogen jets, hydrogen concentrations can locally be above LFL and then create explosive atmospheres with significant volumes.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

11/02656 Accelerating the transfer and diffusion of energy saving technologies steel sector experience – lessons learned

Okazaki, T. and Yamaguchi, M. *Energy Policy*, 2011, 39, (3), 1296–1304.

The purpose of this paper is to explore the effectiveness of global voluntary sectoral approach for technology diffusion and transfer based on steel sector experience. The goal is to contribute toward building a worldwide low-carbon society by manufacturing goods with less energy through international cooperation of each sector. The authors believe that the voluntary sectoral approach is an effective method with political and practical feasibilities, and hope to see the continued growth of more initiatives based on this approach.

11/02657 Combustion performance of an aluminum melting furnace operating with natural gas and liquid fuel

Nieckele, A. O. *et al. Applied Thermal Engineering*, 2011, 31, (5), 841–851.

The choice of liquid or gas fuel to be used in an industrial furnace can be of extreme importance, having a direct effect on its performance, on the level of pollutants emissions, and on the equipment working life. These factors are highly dependent on the combustion process and on factors such as the flame shape and the temperature and heat flux distributions within the furnace. In the present work, numerical simulations were carried out, using the finite volume method, with the purpose of analysing and comparing the combustion process inside an aluminium furnace when operating with two types of fuel: a spray of liquid oil and a jet of natural gas, both reacting with air. The results showed the possible damages that may be caused by the combustion process if long or too intense and concentrated flames are present, increasing the wall temperatures and compromising the heat flux on the aluminium surface.

11/02658 Development of method for estimation of world industrial energy consumption and its application

Fujimori, S. and Matsuoka, Y. *Energy Economics*, 2011, 33, (3), 461–473.

The energy balances published by the International Energy Agency (IEA) is a valuable source of energy statistics covering world energy supply and demand. However, some issues arise when these data are analysed or used directly. Even when industrial energy consumption alone is examined, at least three types of issues are encountered: missing data, large amounts of misallocated data in some countries, and numerous unrealistic outliers in the time-series variations. When only a few regions are considered, data can be looked at one by one and modified. In this case, these issues are overcome with a systematic method because the data covers world including more than 100 regions. This paper proposes a data reconciliation method to treat these issues, and describes its application to world industrial energy consumption. As a result of its application, it is found that the three issues mentioned above seemed to be overcome. The degree of the reconciliation by region showed that OECD countries' degree tends to be smaller than those of non-OECD countries. However, not all of the OECD countries have low values and some countries, such as the USA, have high values.

11/02659 Development of new wire mesh packings for improving the performance of zero carryover spray tower

Kumar, R. *et al. Energy*, 2011, 36, (2), 1362–1374.

This paper presents the experimental results of chemical dehumidification of air by aqueous $CaCl_2$ liquid desiccant. A new design of the spray tower for eliminating carryover without increasing the pressure drops has been done. New types of wire mesh packings have also been proposed for improving the performance of the conventional spray tower. Three different configurations of the wire mesh packings have been designed and tested to improve the performance of tower with least cost addition. Experimental results have been presented in terms of 'change in specific humidity', rate of moisture removal and tower effectiveness. Comparison of the experimental results of towers using these three packings with the conventional spray tower show improvement in the performance of spray tower (30%) without mounting air side pressure drop burden. Mass flow rate of liquid desiccant, mass flow rate of air, inlet specific humidity of air, and concentration of desiccant solution are found to have major influence on the performance.

11/02660 Energy consumption and CO_2 emissions of the European glass industry

Schmitz, A. *et al. Energy Policy*, 2011, 39, (1), 142–155.

An in-depth analysis of the energy consumption and CO_2 emissions of the European glass industry is presented. The analysis is based on data of the European Union (EU) emissions trading scheme (ETS) for the period 2005–2007 (phase I). The scope of this study comprises the European glass industry as a whole and its seven subsectors. The analysis is based on an assignment of the glass installations (approximately 450) within the EU ETS to the corresponding subsectors and an adequate matching of the respective production volumes. A result is the assessment of the overall final energy consumption (fuel, electricity) as well as the overall CO_2 emissions (process, combustion and indirect emissions) of the glass industry and its subsectors in the EU's 25/27 member states. Moreover, figures on fuel mix as well as fuel intensity and CO_2 emissions intensity (i.e. carbon intensity) are presented for each of the subsectors on aggregated levels and for selected EU member states separately. The average intensity of fuel consumption and direct CO_2 emissions of the EU-25 glass industry decreased from 2005 to 2007 by about 4% and amounted in 2007 to 7.8 GJ and 0.57 t_{CO2} per tonne of saleable product, respectively. The economic energy intensity was evaluated with 0.46 toe/€1000 (EU-27).

11/02661 Flow characteristics in an acoustic bubbling fluidized bed at high temperature

Guo, Q. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (3), 331–337.

The pressure fluctuation of the quartz sand and SiO_2 particles was investigated using pressure transducer in high temperature fluidized bed with sound assistance. The effects of bed temperature, sound wave frequency, and sound pressure level (SPL) on the pressure fluctuation were examined. It indicates that the minimum fluidization velocity decreases with an increase in sound pressure level at the same sound frequency. At the same SPL and bed temperature, there always exists an optimal frequency range achieving good fluidization quality. As the sound frequency increases, the minimum fluidization velocity decreases firstly and then increases. Based on the statistical analysis of pressure signals, the effect of sound frequency on the fluidization quality at high-temperature fluidized bed was presented. On basis of discrete wavelet transform, an original signal was resolved into five-detailed scale signal. Furthermore, the peak frequency for scale 3 detail signal represents the bubbling frequency.

11/02662 Global process industry initiatives to reduce major accident hazards

Pitblado, R. *Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 57–62.

In the past 10 years, the vapour cloud explosion at Texas City, the ammonium nitrate explosion in Toulouse, a pipeline disaster in Belgium, and three near total loss events in Norway have highlighted that major accident process safety is still a serious issue. Hopes that PSM or safety case regulations would reduce process events by 80% have not proven true. The Baker Panel, convened after Texas City developed a series of recommendations, mainly around leadership, incentives, safety culture and more effective implementation of PSM systems. Many US-based companies are working hard to implement the Baker recommendations. In Europe, an approach built around safety barriers, especially relating to technical safety systems, is being widely adopted. The author's company has carried out a global survey of process industry initiatives, for both upstream and downstream activities, to identify what the industry itself is planning to enhance process safety in the next 5–10 years. This paper presents a summary of some of the major programs and initiatives as apply to traditional oil majors, newer national oil companies, and the chemical industry. These are a mixture of Baker recommendations, barrier approaches and tighter integration of process safety and asset integrity. While the factor of 10 improvement achieved in occupational safety over the past 20 years seems unattainable for process safety, a three- to four-fold improvement in the next 20 years does seem possible. This would call for significant effort on the part of operators, but the benefits fully justify the effort.

11/02663 Industrial electricity demand for Turkey: a structural time series analysis

Dilaver, Z. and Hunt, L. C. *Energy Economics*, 2011, 33, (3), 426–436.

This research investigates the relationship between Turkish industrial electricity consumption, industrial value added and electricity prices in order to forecast future Turkish industrial electricity demand. To achieve this, an industrial electricity demand function for Turkey is estimated by applying the structural time series technique to annual data over the period 1960 to 2008. In addition to identifying the size and significance of the price and industrial value added (output) elasticities, this technique also uncovers the electricity underlying energy demand trend (UEDT) for the Turkish industrial sector and is, as far as is known, the first attempt to do this. The results suggest that output and real electricity prices and a UEDT all have an important role to play in driving Turkish industrial electricity demand. Consequently, they should all be incorporated when modelling Turkish industrial electricity demand and the estimated UEDT should arguably be considered in future energy policy decisions concerning the Turkish electricity industry. The output and price elasticities are estimated to be 0.15 and −0.16, respectively, with an increasing (but at a decreasing rate) UEDT and based on the estimated equation, and different forecast assumptions, it is predicted that Turkish industrial electricity demand will be somewhere between 97 and 148 TWh by 2020.

11/02664 New energy strategies in the Swedish pulp and paper industry – the role of national and EU climate and energy policies

Ericsson, K. *et al. Energy Policy*, 2011, 39, (3), 1439–1449.

The Swedish pulp and paper industry has gone through a strategic change in its approach to electricity production and consumption over the past decade. This paper documents this reorientation, which includes increased on-site electricity production, investments and investment plans for wind power, and new partnerships concerning investments in electricity production assets. It also assesses the extent to which these changes can be attributed to key energy and climate policies. The analysis shows that this strategic reorientation has been driven by changes in the underlying economic conditions for the pulp and paper industry, in particular increases in the price of electricity following the Swedish energy market reform in 1996, and the introduction of the EU ETS. The scheme for tradable renewable electricity certificates, on the other hand, has provided a new source of income. While these market-based signals and responses are the most dominant drivers of strategic change, cognitive changes in the pulp and paper industry have also played a role in the strategic reorientation. The cognitive changes concerning the functioning of the electricity market, i.e. the pricing of electricity and influence of the EU ETS, have been particularly important in this regard.

11/02665 Performance evaluation of producer gas burner for industrial application

Panwar, N. L. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1373–1377.

The purpose of this study is to evaluate the performance of premixed type industrial burner with producer gas, in terms of emission, axial and radial flame temperature. The developed burner was a concentric tube type where the air supplied through a central tube, which is surrounded by another one. It having 150 kWth capacity and tested on open core downdraft type gasifier. The burner consists of swirl vane for mixing the air and producer gas, mixing tube and bluff body for flame stabilization. Swirl angle and bluff body diameter was kept constant throughout the study. Burner was evaluated with open core downdraft type gasifier. In order to understand the qualitative differences in the temperature profile and emissions during combustion of producer gas, an experiment was conducted on three-flow rate and air–fuel ratio. Study shows low NO_x and CO emission at $125\,Nm^3\,h^{-1}$ as compared to that of 75 and $100\,Nm^3\,h^{-1}$. Maximum flame temperature (753 °C) was recorded at of 10 cm axial and 10 mm radial distance.

11/02666 Performance of electronic switching circuits based on bipolar power transistors at low temperature

El-Ghanam, S. M. and Abdel Basit, W. *Cryogenics*, 2011, 51, (3), 117–123.

In this paper, the performance of the bipolar power transistor of the type MJE13007 was evaluated under very low temperature levels. The investigation was carried out to establish a baseline on functionality and to determine suitability of this device for use in space applications under cryogenic temperatures. The static and dynamic electrical characteristics of the proposed transistor were studied at low temperature levels ranging from room level (300 K) down to 100 K. From which, it is clear that, several electrical parameters were affected due to operation on such very low temperature range, e.g. the threshold voltage (V_γ) increasing from 0.62 up to 1.05 V; while the current gain h_{FE} decreases significantly from 26 down to 0.54. Also, the capacitance–voltage relationships (C–V) of the collector–base and emitter–base junctions were studied at cryogenic temperatures, where a pronounced decrease was observed in the capacitances value due to temperature decrease. For example, at $F = 50\,kHz$; C_{CB} and C_{BE} decreased from 2.33 nF down to 0.07 nF and from 36.2 down to 12 nF, respectively due to decreasing of temperature level from 300 down to 100 K. Finally, the study was extended to include the dynamic characteristics and switching properties of the tested high-power transistor. The dependency of both the rise and fall times (t_r, t_f) on the temperature shows great variations with temperature.

11/02667 Photocatalytic inactivation of bacteria in a fixed-bed reactor: mechanistic insights by epifluorescence microscopy

Pablos, C. *et al. Catalysis Today*, 2011, 161, (1), 133–139.

The photocatalytic inactivation of *Escherichia coli* bacteria with titanium dioxide immobilized in a fixed-bed reactor has been studied and compared with the results obtained using aqueous titania suspensions. In both cases, the photocatalytic inactivation has been successfully achieved, reaching a 6-log decrease in the concentration of bacteria. The slurry system shows a higher inactivation rate at the beginning of the reaction that decreases progressively, whereas the fixed-bed reactor increases the inactivation rate as the irradiation time increases, leading both catalytic systems to comparable irradiation times for the total inactivation of bacteria, i.e. concentration below the detection limit. This opposite trend seems to be related to differences in the bacteria–TiO_2 interaction, being also observed that the fixed-bed catalytic system is less affected by the competition for the oxidant species of byproducts released after the bacterial cell lysis. Epifluorescence microscopy pictures taken after a dual DAPI/PI staining membrane permeability assay provide mechanistic insights into this different behaviour, showing for the fixed-bed experiments an increase in the damaged bacteria from the very beginning of the reaction, whereas for the slurry system they were not observed until longer irradiation exposition is achieved. These results suggest as hypothesis that although in absolute terms the number of hydroxyl radical attacks could be even lower in the immobilized systems, the damages are more concentrated on the area in which the bacteria–TiO_2 interaction takes place. Although the fixed-bed reactor requires comparable irradiation time for total inactivation of bacteria than that corresponding to the slurry system, it shows minor deactivation and allows the continuous operation without the need of particles removal, making this immobilized system a good alternative to successfully scale-up the photocatalytic disinfection technology.

11/02668 Pressure-drop predictions in a fixed-bed coal gasifier

Luckos, A. and Bunt, J. R. *Fuel*, 2011, 90, (3), 917–921.

In the Sasol synfuels plant in Secunda, Sasol-Lurgi fixed-bed dry-bottom gasifiers are used for the conversion of low-grade bituminous coals to synthesis gas (syngas). The gasifiers are fed with lump coal having a particle size in the range from 5 to 100 mm. Operating experience shows that the average particle size and particle-size distribution (PSD) of feed coal, char and ash influence the pressure drop across the bed and the gas-flow distribution within the bed. These hydrodynamic phenomena are responsible for stable gasifier operation and for the quality and production rate of the syngas. The counter-current operation produces four characteristic zones in the gasifier, namely, drying, de-volatilization, reduction and combustion. The physical properties of the solids (i.e. average particle size, PSD, sphericity and density) are different in each of these zones. Similarly, the chemical composition of the syngas, its properties (temperature, density and viscosity) and superficial velocity vary along the height of the bed. The most popular equation used to estimate the pressure drop in packed beds is that proposed by Ergun. The Ergun equation gives good predictions for non-reacting, isothermal packed beds made of uniformly sized, spherical or nearly spherical particles. In the case of fixed-bed gasifiers, predictions by the Ergun equation based on the average or inlet values of bed and gas flow parameters are unsatisfactory because the bed structure and gas flow vary significantly in the different reaction zones. In this study, the Ergun equation is applied to each reaction zone separately. The total pressure drop across the bed is then calculated as the sum of pressure drops in all zones. It is shown that the total pressure drop obtained this way agrees better with the measured result.

11/02669 Substitution between energy and classical factor inputs in the Chinese steel sector

Smyth, R. *et al. Applied Energy*, 2011, 88, (1), 361–367.

China's steel sector is the largest in the world and has been a major driving force behind China's high rate of economic growth. This sector, however, is also a major consumer of energy and, in particular, coal. As a result, the iron and steel sector in China is a major contributor to greenhouse gas emissions and other pollutants. This study examines the potential for inter-factor substitution between capital, energy and labour in the Chinese steel sector and find that capital and energy and energy and labour are substitutes. This result suggests that removal of price ceilings on energy would tend to reduce energy use and increase capital intensiveness. While the potential for substitution between energy and labour is less than that between energy and capital, the elasticity of substitution between energy and labour is high compared with previous findings for other countries. This fact suggests that there may be potential for substituting labour for energy, given China's abundance of labour.

11/02670 Systems analysis of integrating biomass gasification with pulp and paper production – effects on economic performance, CO_2 emissions and energy use

Wetterlund, E. *et al. Energy*, 2011, 36, (2), 932–941.

This paper evaluates system aspects of biorefineries based on biomass gasification integrated with pulp and paper production. As a case the Billerud Karlsborg mill is used. Two biomass gasification concepts are considered: biomass integrated gasification dimethyl ether production (BIGDME) and biomass integrated gasification combined cycle (BIGCC). The systems analysis is made with respect to economic performance, global CO_2 emissions and primary energy use. As reference cases, BIGDME and BIGCC integrated with district heating are considered. Biomass gasification is shown to be potentially profitable for the mill. The results are highly dependent on assumed energy market parameters, particularly policy support. With strong policies promoting biofuels or renewable electricity, the calculated opportunity to invest in a gasification-based biorefinery exceeds investment cost estimates from the literature. When integrated with district heating the BIGDME case performs better than the BIGCC case, which shows high sensitivity to heat price and annual operating time. The BIGCC cases show potential to contribute to decreased global CO_2 emissions and energy use, which the BIGDME cases do not, mainly due to high biomass demand. As biomass is a limited resource, increased biomass use due to investments in gasification plants will lead to increased use of fossil fuels elsewhere in the system.

11/02671 Time scale analysis for fluidized bed melt granulation I: granule–granule and granule–droplet collision rates

Chua, K. W. *et al. Chemical Engineering Science*, 2011, 66, (3), 318–326.
Fluidized bed spray granulators (FBMG) are widely used in the process industry for particle size growth; a desirable feature in many products, such as granulated food and medical tablets. In this paper, the first in a series of four discussing the rate of various microscopic events occurring in FBMG, theoretical analysis coupled with CFD simulations have been used to predict granule–granule and droplet–granule collision time scales. The granule–granule collision time scale was derived from principles of kinetic theory of granular flow (KTGF). For the droplet–granule collisions, two limiting models were derived; one is for the case of fast droplet velocity, where the granule velocity is considerable lower than that of the droplet (ballistic model) and another for the case where the droplet is travelling with a velocity similar to the velocity of the granules. The hydrodynamic parameters used in the solution of the above models were obtained from the CFD predictions for a typical spray fluidized bed system. The granule–granule collision rate within an identified spray zone was found to fall approximately within the range of 10^{-2}–10^{-3} s, while the droplet–granule collision was found to be much faster, however, slowing rapidly (exponentially) when moving away from the spray nozzle tip. Such information, together with the time scale analysis of droplet solidification and spreading, discussed in parts II and III of this study, are useful for probability analysis of the various event occurring during a granulation process, which then lead to be better qualitative and, in part IV, quantitative prediction of the aggregation rate.

11/02672 Time scale analysis for fluidized bed melt granulation II: binder spreading rate

Chua, K. W. *et al.Chemical Engineering Science*, 2011, 66, (3), 327–335.
The spreading time of liquid binder droplet on the surface a primary particle is analysed for fluidized bed melt granulation (FBMG). As discussed in the first paper of this series the droplet spreading rate has been identified as one of the important parameters affecting the probability of particles aggregation in FBMG. In this paper, the binder droplet spreading time has been estimated using computational fluid dynamic modelling based on volume of fluid approach. A simplified analytical solution has been developed and tested to explore its validity for predicting the spreading time. For the purpose of models validation, the droplet spreading evolution was recorded using a high speed video camera. Based on the validated model, a generalized correlative equation for binder spreading time is proposed. For the operating conditions considered here, the spreading time for polyethylene glycol (PEG1500) binder was found to fall within the range of 10^{-2} to 10^{-5} s. The study also included a number of other common binders used in FBMG. The results obtained here will be further used in part III, where the binder solidification rate is discussed.

11/02673 Time scale analysis for fluidized bed melt granulation III: binder solidification rate

Chua, K. W. *et al. Chemical Engineering Science*, 2011, 66, (3), 336–341.
In parts I and II of this study, the authors discussed the time scale of granule–granule collision, droplet–granule collision and droplet spreading in fluidized bed melt granulation (FBMG). In this third part they consider the rate at which the binder solidifies. Simple analytical solution, based on classical formulation for conduction across a semi-infinite slab, was used to obtain a generalized equation for binder solidification time. A multi-physics simulation package (Comsol) was used to predict the binder solidification time for various operating conditions usually considered in FBMG. The simulation results were validated with experimental temperature data obtained with a high speed infrared camera during solidification of 'macroscopic' (millimetre scale) droplets. For the range of microscopic droplet size and operating conditions considered for a FBMG process, the binder solidification time was found to fall approximately between 10^{-3} and 10^{-1} s. This is the slowest compared to the other three major FBMG microscopic events discussed in this series (granule–granule collision, granule–droplet collision and droplet spreading).

11/02674 Two-dimensional computational fluid dynamics simulation of coal combustion in a circulating fluidized bed combustor

Zhou, W. *et al. Chemical Engineering Journal*, 2011, 166, (1), 306–314.
A computational fluid dynamics (CFD) approach was applied to simulate the air-coal two-phase flow and combustion characteristics in a 50 kW circulating fluidized bed (CFB) combustor. Eulerian–Granular multiphase model with a drag coefficient correction based on the extended energy-minimization multi-scale (EMMS/matrix) model was used to study the gas–solid hydrodynamics. One energy conservation equation was applied to the mixture of gases and solids, considering heat conduction, heat convection and heat sources from chemical reactions. Reactions during coal combustion included moisture evaporation, dry coal devolatilization, volatile combustion, char combustion and char gasification. The model predicted the main features of the complex gas–solid flow, including the cluster formation of the solid phase along the walls, the flow structure of upward flow in the core and downward flow in the annular region. The voidage and temperature profiles in the furnace and the concentrations of gas components from the riser were validated with experimental data. Distributions of reaction rates in the riser were also obtained. This indicates a promising way to simulate the coal combustion in CFB to help understanding the combustion mechanism and designing new combustion technologies.

10 SPACE HEATING AND COOLING/HEAT PUMPS

11/02675 A review of thermally activated cooling technologies for combined cooling, heating and power systems

Deng, J. *et al. Progress in Energy and Combustion Science*, 2011, 37, (2), 172–203.
The state of the art of research in thermally activated cooling technologies for combined cooling, heating and power (CCHP) systems are presented here in detail, mainly including absorption and adsorption refrigeration, and desiccant cooling. A basic description of thermally activated cooling is given first. Next, according to the diverse categories of thermally activated cooling, the working principles, products markets available or under development, diverse combinations of thermally activated technologies in CCHP applications or experimental units, and existing problems are listed and discussed through a comprehensive review of the literature. Furthermore, more recent advanced research of thermally activated cooling in innovative concept, material and technologies are included. Finally, detailed summary and suggestions are proposed for proper utilization of thermally activated cooling technologies, and the future development roadmap and preferred strategies are also outlined. The review will demonstrate that thermally activated cooling technologies are attractive alternatives that not only serve the need for air-conditioning, refrigeration, dehumidification, and augmenting prime movers, but also can meet the demand for energy conservation and environmental protection.

11/02676 Air-source heat pump carbon footprints: HFC impacts and comparison to other heat sources

Johnson, E. P. *Energy Policy*, 2011, 39, (3), 1369–1381.
European governments see that heat pumps could reduce carbon emissions in space- and hot-water heating. EU's Renewable Energy Directive designates heat pumps as renewable – eligible for various subsidies – if their carbon footprints are below an implied, average threshold. This threshold omits carbon generated by manufacture and emission of a heat-pump's fluorocarbon refrigerant. It also omits the footprint of the heat pump's hardware. To see if these omissions are significant, this study calculated carbon footprints of representative, residential heat pumps in the UK. Three findings emerged. First, in relation to power generation, which accounts for most of a heat-pump's greenhouse-gas emissions, fluorocarbons add another 20% to the footprint. Second, at UK efficiencies a heat-pump footprint (in kg CO_2e emitted per kWh delivered) is comparable or higher than footprints of gaseous fuels used in heating. It is lower than the footprint of heating oil and far lower than the footprints of solid fuels. Third, production and disposal of a heat pump's hardware is relatively insignificant, accounting for only 2–3% of the overall heat-pump footprint. Sensitivities to the results were assessed: key factors are footprint of electricity generation, F-gas composition and leak rates and type of wall construction.

11/02677 An experimental investigation of the global environmental impact of the R22 retrofit with R422D

Aprea, C. and Maiorino, A. *Energy*, 2011, 36, (2), 1161–1170.
In recent years a new refrigerant, R422D, has been introduced as substitute of R22 for refrigeration systems. This new fluid is an easy-to-use, non-ozone-depleting HFC refrigerant and, differently from its predecessor (R407C), it is compatible with mineral oil. However, R422D has a very high GWP (global warming potential), and it tends to worsen the efficiency of retrofitted R22 systems. Consequently, even if R422D respects the limits of Montreal Protocol, its global environmental impact could be high. An experimental analysis is reported in terms of TEWI aimed to identify the global environmental impact of R22 systems retrofitted with R422D. For this purpose, a direct expansion refrigerator was considered for commercial applications and energy consumption with the temperature of the cold reservoir set to −5, 0, 5, 10 °C investigated. The experimental investigation

confirmed that the system, when retrofitted with R422D, leads to an increase of TEWI. Therefore an optimization analysis aimed to eco-friendly scenarios was performed.

11/02678 Compact/micro-heat exchangers – their role in heat pumping equipment

Kew, P. A. and Reay, D. A. *Applied Thermal Engineering*, 2011, 31, (5), 594–601.

Compact and micro-heat exchangers have many advantages over their larger counterparts, particularly when used to handle clean fluid streams, either single- or two-phase. Probably the most exciting feature of such heat exchangers is their ability to operate with close approach temperatures, leading to high effectiveness. This can be particularly beneficial when the exchangers are used in power-producing or power-consuming systems, where the improved heat exchanger effectiveness can be immediately realized in higher power outputs or reduced power consumption. In the case of heat pumping equipment – the most common examples being air–water or air–air vapour compression cycle heat pumps for domestic heating – this manifests itself in an increased coefficient of performance that reduces CO_2 emissions due to a lower energy input needed to drive the compressor. This paper gives a snapshot of some of the work carried out in five countries, Austria, Japan, Sweden, USA and the UK, within the IEA Heat Pump Implementing Agreement Annex 33 to identify the heat exchangers that can most benefit heat pump cycles, with a strong emphasis on micro-channel heat transfer. It also presents data on other research relevant to the subject, highlighting the 'micro' size range – the theme of the MNF 2009 conference.

11/02679 Computational study of film cooling from single and two staggered rows of novel semi-circular cooling holes including coolant plenum

Asghar, F. H. and Hyder, M. J. *Energy Conversion and Management*, 2011, 52, (1), 329–334.

Computational analysis of film cooling effectiveness using novel semi-circular hole shapes with streamwise inclination of 30° has been carried out. Velocity profiles from the separate coolant plenum geometry are used for inlet condition to cooling holes. Realizable k–ε turbulence model with enhanced wall treatment is used for turbulence modelling in simulations. It is observed that coolant jet heights for one row and two staggered rows of semi-circular holes are lower than that for one row of circular holes. The centreline and laterally averaged effectiveness values from a row of semi-circular holes are found almost same as that from a row of circular holes due to the less jet lift-off in semi-circular case. Semi-circular hole utilizes half of the coolant mass required for full circular hole for producing the same blowing ratio, so same level of effectiveness from semi-circular holes as that from full circular holes is great advantage. The centreline and laterally effectiveness values from two staggered rows of semi-circular holes are found much higher than a single row of full circular hole case at all streamwise regions at all blowing ratios tested. Along with centreline effectiveness and laterally averaged effectiveness values, the non-dimensional temperature profiles at $(x/D, z/D) = (5.0, 0.0)$, non-dimensional temperature contours and velocity vectors at plane $x/D = 5.0$ are also presented. Counter-rotating vortex pairs from row of semi-circular holes are found to be weak and of lower size as compare to that from a row of full circular holes.

11/02680 Control performance of a dedicated outdoor air system adopting liquid desiccant dehumidification

Xiao, F. *et al. Applied Energy*, 2011, 88, (1), 143–149.

Liquid desiccant is energy efficient for dehumidification in air-conditioning systems. In this study, a novel dedicated outdoor air system (DOAS) adopting lithium chloride solution as liquid desiccant is proposed to process supply air. The DOAS mainly consists of a membrane-based total heat exchanger, a liquid dehumidifier, a regenerator and a dry cooling coil. It can realize independent temperature and humidity controls for supply air. Control strategies for the supply air dehumidification and cooling process as well as the desiccant solution regeneration process in the DOAS are developed and verified. The control performances of the proposed dedicated outdoor air system are investigated at different operation conditions by simulation tests. The results show that the DOAS is more suitable for hot and humid climates. The effects of the total heat exchanger on the performance of the DOAS are also evaluated. It can improve the system energy performance by 19.9–34.8%.

11/02681 Convective heat transfer and solid conversion of reacting particles in a copper(II) chloride fluidized bed

Daggupati, V. N. *Chemical Engineering Science*, 2011, 66, (3), 460–468.

This paper develops a predictive model of convective heat transfer and conversion of cupric chloride particles in a fluidized bed reactor of a copper–chlorine (Cu–Cl) cycle of thermochemical hydrogen production. The hydrolysis reaction of particles in the fluidized bed is endothermic and it requires excess steam for complete conversion of cupric chloride solid. The excess steam supply may be used for partial heat supply to the endothermic reaction, and also to avoid defluidization in the bed. To avoid defluidization, the change of gas flow in the bed due to the reaction should be minimized at a given operating condition. The model predicts the maximum possible steam inlet temperature, steam conversion, amount of partial heat supply, and also gas flow rates through the bed to avoid defluidization. The new model presents significant new insight by analysing the hydrodynamic and mass transport processes, considering the equilibrium limitation on the conversion of cupric chloride solid. The model results indicate that the chemical reaction requires a high mole ratio of steam for complete conversion of cupric chloride particles. The maximum steam conversion is limited by temperature, pressure, and the presence of hydrogen chloride gas. The maximum conversion of steam at 400 °C is 3.75% and it requires excess steam of 12.8 moles per unit mole of cupric chloride solid for complete conversion of solid. The heat supply by steam for the reaction, as well as raising the solid feed to the reaction temperature, varies with reaction temperature. The paper also adds significant new insight by analysing the steam flow requirement in terms of temperature, conversion rate, and quality of fluidization. Additional new results are presented and applications discussed for the Cu–Cl cycle of nuclear hydrogen production.

11/02682 Convective heat transfer coefficients for exterior building surfaces: existing correlations and CFD modelling

Defraeye, T. *et al. Energy Conversion and Management*, 2011, 52, (1), 512–522.

Convective heat transfer at exterior building surfaces has an impact on the design and performance of building components such as double-skin facades, solar collectors, solar chimneys and ventilated photovoltaic arrays, and also affects the thermal climate and cooling load in urban areas. In this study, an overview is given of existing correlations of the exterior convective heat transfer coefficient (CHTC) with the wind speed, indicating significant differences between these correlations. As an alternative to using existing correlations, the applicability of computational fluid dynamics (CFD) to obtain forced CHTC correlations is evaluated, by considering a cubic building in an atmospheric boundary layer. Steady Reynolds-averaged Navier–Stokes simulations are performed and, instead of the commonly used wall functions, low-Reynolds number modelling (LRNM) is used to model the boundary-layer region for reasons of improved accuracy. The flow field is found to become quasi independent of the Reynolds number at Reynolds numbers of about 10^5. This allows limiting the wind speed at which the CHTC is evaluated and thus the grid resolution in the near-wall region, which significantly reduces the computational expense. The distribution of the power-law CHTC-U_{10} correlation over the windward and leeward surfaces is presented (U_{10} = reference wind speed at 10 m height). It is shown that these correlations can be accurately determined by simulations with relatively low wind speed values, which avoids the use of excessively fine grids for LRNM, and by using only two or three discrete wind speed values, which limits the required number of CFD simulations.

11/02683 Development of the performance of an alpha-type heat engine by using elbow-bend transposed-fluids heat exchanger as a heater and a cooler

El-Ehwany, A. A. *et al. Energy Conversion and Management*, 2011, 52, (2), 1010–1019.

In this work, elbow-bend heat exchangers were suggested to be used as a heater and a cooler in an alpha-type Stirling engine. Elbow-bend heat exchanger is a bank of tubes arranged in a quadrant either in line or staggered with different normal and parallel pitches. Eight of such heat exchangers having different dimensions were tested experimentally for steady flow (in a previous work by the same authors). The experimental results were correlated for heat transfer and pressure drop. In the present work, an alpha-Stirling engine with twin parallel cylinders on a common crankcase was suggested to use elbow-bend heat exchangers as a heater and a cooler. In the heater, the flue gases flow inside the tubes and the working gas fluctuates about the heater tubes. In the cooler, the coolant flows inside the cooler tubes and the gas flows about the cooler tubes. A computer program in the form of a spread sheet was prepared to solve numerically the engine cycle in the vision of Schmidt theory. Upon calculations, the most suitable stroke/bore ratio, phase angle and speed were found out for nitrogen as a working gas. In a comparison among the proposed engine and practical ones by the literature, it was found that; the proposed engine delivers about 13% more power per cm^3 per ΔT than those by the literature at high thermal efficiency level.

11/02684 Dielectric properties of liquid refrigerants: facts and trends

Ribeiro, A. P. C. and Nieto de Castro, C. A. *International Journal of Refrigeration*, 2011, 34, (2), 393–401.

In this paper the authors analyse the situation for the dielectric properties of the refrigerants, from the experimental and theoretical point of view. Examples of the predictive power of simple models will illustrate the existing tools for electrical permittivity and dipole moment prediction and correlation. The relation of Báron and Buep was analysed and extended to include the effects of pressure variation. Analogies between the Vedam equation and rough hard-sphere theory of transport properties were encountered and discussed.

11/02685 Dynamic model for a heat exchanger tube rupture discharging a high-pressure flashing liquid into a low-pressure liquid-filled shell

Ennis, C. J. *et al. Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 111–121.

Shell-tube type heat exchangers are often used to exchange heat between a high-pressure fluid and a low-pressure fluid. The pressure difference between these two fluids could be high. In the event of tube rupture, a problem may arise in that a transient pressure rise phenomenon could occur due to the flashing of the high-pressure sub-cooled fluid in the tube into the low-pressure shell, which may cause the shell to rupture with subsequent damage to equipment. This paper presents a dynamic model to describe the transient phenomenon occurring on the shell side following various scenarios of tube rupture. The spatial and temporal aspects of the flow transients along the pressure safety valve riser are accounted for by solving the one-dimensional continuity and momentum hyperbolic partial differential equations as applied to the liquid-filled riser. The dynamics of the attached piping system are also accounted for via two mechanistic models; the first is based on an inertial-resistive assumption of the fluids in this system, while the other is based on the assumption of anechoic perturbations passing through a long section of the attached piping. The latter is justified in cases where the attached piping is long enough such that reflections from the downstream end do not interfere with transients occurring in the shell during the initial phase of fluid flashing into the shell side following rupture. The various phases of this phenomenon are described, however the paper focuses on the initial phase of the phenomenon during which shell overpressure may be encountered. The model is applied to two ethylene heaters in tandem; the first uses propylene on the shell side to heat the ethylene on the tube side, while the second uses methanol, also on the shell side. The ratio between the shell design pressure to the tube design pressure in these two heaters are 0.169 and 0.154, respectively, hence the motivation to accurately model the transients involved in this phenomenon. The practical aspects and discussion around techniques to alleviate potential overpressure scenarios due to tube rupture are emphasized throughout the paper.

11/02686 Economic optimization of shell and tube heat exchanger based on constructal theory

Azad, A. V. and Amidpour, M. *Energy*, 2011, 36, (2), 1087–1096.

In this paper, the new approach of constructal theory has been employed to design shell and tube heat exchangers. Constructal theory is a new method for optimal design in engineering applications. The purpose of this paper is optimization of shell and tube heat exchangers by reduction of total cost of the exchanger using the constructal theory. The total cost of the heat exchanger is the sum of operational costs and capital costs. The overall heat transfer coefficient of the shell and tube heat exchanger is increased by the use of constructal theory. Therefore, the capital cost required for making the heat transfer surface is reduced. Moreover, the operational energy costs involving pumping in order to overcome frictional pressure loss are minimized in this method. Genetic algorithm is used to optimize the objective function which is a mathematical model for the cost of the shell and tube heat exchanger and is based on constructal theory. The results of this research represent more than 50% reduction in costs of the heat exchanger.

11/02687 Enhanced laminated composite phase change material for energy storage

Darkwa, J. and Zhou, T. *Energy Conversion and Management*, 2011, 52, (2), 810–815.

This paper summarizes studies undertaken towards the development of a laminated composite aluminium/hexadecane phase change material (PCM) drywall based on previous analytical work. The study also covered the selection and testing of various types of adhesive materials and identified polyvinyl acetate (PVA) material as a suitable bonding material. For the purpose of comparison pure hexadecane and composite aluminium/hexadecane samples were developed and tested. The test results revealed faster thermal response by the aluminium/hexadecane sample regarding the rate of heat flux and also achieved about 10% and 15% heat transfer enhancements during the charging and discharging periods respectively. Its measured effective thermal conductivity also increased remarkably to 1.25 W/mK as compared with 0.15 W/mK for pure hexadecane. However there was about 5% less total cumulative thermal energy discharged at the end of the test which indicates that its effective thermal capacity was reduced by the presence of the aluminium particles. The study has shown that some of the scientific and technical barriers associated with the development of laminated composite PCM drywall systems can be overcome but further investigations of effects of adhesive materials are needed.

11/02688 Evaluation of a solar intermittent refrigeration system for ice production operating with ammonia/lithium nitrate

Rivera, W. *et al. Solar Energy*, 2011, 85, (1), 38–45.

A novel solar intermittent refrigeration system for ice production developed in the Centro de Investigación en Energía of the Universidad Nacional Autónoma de México is presented. The system operates with the ammonia/lithium nitrate mixture. The system developed has a nominal capacity of 8 kg of ice/day. It consists of a cylindrical parabolic collector acting as generator–absorber. Evaporator temperatures as low as −11 °C were obtained for several hours with solar coefficients of performance up to 0.08. It was found that the coefficient of performance increases with the increment of solar radiation and the solution concentration. A dependency of the coefficient of performance was not founded against the cooling water temperature. Also it was found that the maximum operating pressure increases meanwhile the generation temperature decreases with an increase of the solution concentration.

11/02689 Exergy analysis for quasi two-stage compression heat pump system coupled with ejector

Xu, S. and Ma, G. *Experimental Thermal and Fluid Science*, 2011, 35, (4), 700–705.

Ejectors are simple mechanical components, can utilize high pressure energy from liquid in the quasi two-stage compression heat pump system coupled with scroll compressor, and the performance of the heat pump system can be further improved. According to thermal analysis model based on the first and second law of thermodynamics, the heat pump prototype has been developed and comprehensively tested, the influence of ejector on the heat pump system was exergetically analysed using experimental data of the prototype. The results show that, compressor has the greatest exergy loss, amounts to about 77% of the total exergy; ejector can recover the fluid pressure exergy in supplementary circuit compared with the throttling element in the quasi two-stage compression heat pump system, decreases the exergy loss of compressor; and the exergetic efficiency can be improved about 3–5%, while the exergy output remains nearly constant.

11/02690 Experimental evaluation of the new solid desiccant heat pump system in Asia-Pacific climatic conditions

Enteria, N. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 243–257.

This study investigates the new solid desiccant heat pump system applied in the outdoor air conditions of the Asia-Pacific Region. The new system operates in a cyclic process of air cooling/dehumidification and air heating/regeneration as opposed to the typical solid desiccant heat pump system. The experimental set-up was constructed to test the performance of the system. Several combinations of the outdoor air and return air temperature and humidity ratios were used in the investigation. The outdoor air conditions range from warm and very humid (33 °C and 80%) to mild temperature and humidity (28 °C and 60%). The indoor air conditions ranges from 28 °C and 60% to 26 °C and 40%. The result shows the system was good in the reduction of air latent energy content compared to the reduction of air sensible energy content. The system reduced up to 10 g/kg of air humidity ratio even at outdoor air humidity ratio of above 25 g/kg with high outdoor air temperature of 33 °C. The system higher coefficient of performance reached the maximum value of 5.7. The system lowest coefficient of performance was 2.9. The present system coefficient of performance is higher than the ordinary vapour compression heat pump system.

11/02691 Experimental studies of a steam jet refrigeration cycle: effect of the primary nozzle geometries to system performance

Ruangtrakoon, N. *et al. Experimental Thermal and Fluid Science*, 2011, 35, (4), 676–683.

This paper describes an experimental investigation of a steam jet refrigeration. A 1 kW cooling capacity experimental refrigerator was constructed and tested. The system was tested with various operating temperatures and various primary nozzles. The boiler saturation temperature ranked from 110 to 150 °C. The evaporator temperature was fixed at 7.5 °C. Eight primary nozzles with difference geometries were used. Six nozzles have throat diameters ranked from 1.4 to 2.6 mm with exit Mach number of 4.0. Two remained nozzles have equal throat diameter of 1.4 mm but difference exit Mach number, 3.0 and 5.5. The experimental results show that the geometry of the primary nozzle has strong effects to the ejector performance and therefore the system COP.

11/02692 Flow boiling heat transfer and pressure drop characteristics of CO_2 in horizontal tube of 4.57-mm inner diameter

Oh, H.-K. and Son, C.-H. *Applied Thermal Engineering*, 2011, 31, (2–3), 163–172.

This paper presents the flow boiling heat transfer and pressure drop of CO_2 (R744) in a horizontal tube. The test tube had an inner diameter of 4.57 mm, with a 0.89-mm wall thickness and length of 4.2 m. Experiments were carried out for heat fluxes ranging from 10 to 40 kW/m^2K, mass fluxes ranging from 200 to 1000 kg/m^2s, and saturation temperatures ranging from 0 to 40 °C. The boiling heat transfer of CO_2 has a greater effect on nucleate boiling than convective boiling and highly depends on the vapour quality, heat flux, and saturation temperature. The boiling heat transfer coefficient of CO_2 increases with a decrease in the inner tube diameter. In a comparison to previous boiling heat transfer correlations, the correlation showed fairly good agreement with the experimental data for CO_2. The boiling pressure drop of CO_2 increased with an increase in the mass flux and decreased with an increase in the saturation temperature. None of the empirical correlations from the existing literature were able to predict the pressure drop of CO_2 in good agreement with the experimental data. Therefore, it is necessary to develop a reliable and accurate prediction for estimating the boiling pressure drop of CO_2.

11/02693 Gas-phase saturation and evaporative cooling effects during wet compression of a fuel aerosol under RCM conditions

Goldsborough, S. S. *et al. Combustion and Flame*, 2011, 158, (1), 57–68.

Wet compression of a fuel aerosol has been proposed as a means of creating gas-phase mixtures of involatile diesel-representative fuels and oxidizer + diluent gases for rapid compression machine (RCM) experiments. The use of high concentration aerosols (e.g. approximately 0.1 mL_{fuel}/L_{gas}, approximately 1×10^9 droplets/L_{gas} for stoichiometric fuel loading at ambient conditions) can result in droplet–droplet interactions which lead to significant gas-phase fuel saturation and evaporative cooling during the volumetric compression process. In addition, localized stratification (i.e. on the droplet scale) of the fuel vapour and of temperature can lead to non-homogeneous reaction and heat release processes – features which could prevent adequate segregation of the underlying chemical kinetic rates from rates of physical transport. These characteristics are dependent on many factors including physical parameters such as overall fuel loading and initial droplet size relative to the compression rate, as well as fuel and diluent properties such as the boiling curve, vaporization enthalpy, heat capacity, and mass and thermal diffusivities. This study investigates the physical issues, especially fuel saturation and evaporative cooling effects, using a spherically-symmetric, single-droplet wet compression model. *n*-Dodecane is used as the fuel with the gas containing 21% O_2 and 79% N_2. An overall compression time and compression ratio of 15.3 ms and 13.4 are used, respectively. It is found that smaller droplets (d_0 approximately 2–3 μm) are more affected by 'far-field' saturation and cooling effects, while larger droplets ($d_0 \sim 14$ μm) result in greater localized stratification of the gas-phase due to the larger diffusion distances for heat and mass transport. Vaporization of larger droplets is more affected by the volumetric compression process since evaporation requires more time to be completed even at the same overall fuel loading. All of the cases explored here yield greater compositional stratification than thermal stratification due to the high Lewis numbers of the fuel–air mixtures ($Le_g \sim 3.8$).

11/02694 General thermodynamic performance of irreversible absorption heat pump

Zhao, X. *et al. Energy Conversion and Management*, 2011, 52, (1), 494–499.

The absorption heat pump (AHP) was studied with thermodynamics. A four reservoirs model of absorption heat pump was established considering the heat resistance, heat leak and the internal irreversibility. The reasonable working regions, the performance effects of irreversibility, heat leak and the correlation of four components were studied. When studying the effects of internal irreversibility, two internal irreversibility parameters (I_{he} for generator–absorber assembly and I_{re} for evaporator–condenser assembly) were introduced to distinguish the different effects. When studying the heat transfer relations of four components, a universal relationship between the main parameters were deduced. The results which have more realized meaning show that, the reduction of the friction, heat loss, and internal dissipations of the evaporator–condenser assembly are more important than its reduction of generator–absorber assembly, and lessening the heat leak of generator are more important than its reduction of other components to improve the AHP performance.

11/02695 Heat exchangers and the performance of heat pumps – analysis of a heat pump database

Kim, D. S. *et al. Applied Thermal Engineering*, 2011, 31, (5), 911–920.

Heat pumping is a highly energy-efficient technology that could help reduce energy and environmental problems. The efficiency of a heat pump greatly depends on the individual and integral performance of the components inside. In this study, heat pump performance is investigated with a special focus on heat exchangers. Experimental data obtained from comprehensive heat pump measurements performed at the Austrian Institute of Technology were analysed with the help of thermodynamic models developed for this purpose. The analysis shows that the performance of heat exchangers varies widely resulting in substantial COP differences among the heat pumps. The models and methodology developed in this study are found capable of extracting useful information from measurement data quickly and accurately and could be useful for the industry.

11/02696 Heat transfer characteristics of spirally-coiled circular fin-tube heat exchangers operating under frosting conditions

Lee, M. *et al. International Journal of Refrigeration*, 2011, 34, (1), 328–336.

The objective of this study is to investigate the heat transfer characteristics of spirally-coiled circular fin-tube heat exchangers under frosting conditions. The heat transfer rate, pressure drop, frost thickness, and Nusselt number of the heat exchanger were measured and analysed by varying the fin pitch and number of tube rows under frosting conditions. In addition, the Nusselt number of the spirally-coiled circular fin-tube exchanger was compared with those of flat plate fin-tube heat exchangers with discrete fins. An empirical correlation of the Nusselt number was developed as a function of the Reynolds number, dimensionless fin pitch normalized by the hydraulic diameter, i.e. D_h/F_p, Fourier number, and number of tube rows. The measured Nusselt number was consistent with the predicted value with mean and average deviations of 3.5% and 0.3%, respectively.

11/02697 Heat transfer using a correlation by neural network for natural convection from vertical helical coil in oil and glycerol/water solution

Colorado, D. *et al. Energy*, 2011, 36, (2), 854–863.

A physical–empirical model is designed to describe heat transfer of helical coil in oil and glycerol/water solution. It includes an artificial neural network (ANN) model working with equations of continuity, momentum and energy in each flow. The discretized equations are coupled using an implicit step-by-step method. The natural convection heat transfer correlation based on ANN is developed and evaluated. This ANN considers Prandtl number, Rayleigh number, helical diameter and coils turns number as input parameters; and Nusselt number as output parameter. The best ANN model was obtained with four neurons in the hidden layer with good agreement ($R > 0.98$). Helical coil uses hot water for the inlet flow; heat transfer by conduction in the internal tube wall is also considered. The simulated outlet temperature is carried out and compared with the experimental database in steady-state. The numerical results for the simulations of the heat flux, for these 91 tests in steady-state, have a $R \geq 0.98$ with regard to experimental results. One important outcome is that this ANN correlation is proposed to predict natural convection heat transfer coefficient from helical coil for both fluids: oil and glycerol/water solution, thus saving time and improving general system performance.

11/02698 Influence of nanofluids on parallel flow square microchannel heat exchanger performance

Mohammed, H. A. *et al. International Communications in Heat and Mass Transfer*, 2011, 38, (1), 1–9.

The effects of using various types of nanofluids and Reynolds numbers on heat transfer and fluid flow characteristics in a square shaped microchannel heat exchanger (MCHE) is numerically investigated in this study. The performance of an aluminium MCHE with four different types of nanofluids [aluminium oxide (Al_2O_3), silicon dioxide (SiO_2), silver (Ag), and titanium dioxide (TiO_2)], with three different nanoparticle volume fractions of 2%, 5% and 10% using water as base fluid is comprehensively analysed. The three-dimensional steady, laminar developing flow and conjugate heat transfer governing equations of a balanced MCHE are solved using the finite volume method. The MCHE performance is evaluated in terms of temperature profile, heat transfer rate, heat transfer coefficient, pressure drop, wall shear stress pumping power, effectiveness, and overall performance index. The results reveal that nanofluids can enhance the thermal properties and performance of the heat exchanger while having a slight increase in pressure drop. It was also found that increasing the Reynolds number causes the pumping power to increase and the effectiveness to decrease.

11/02699 Investigation of viscosity and thermal conductivity of SiC nanofluids for heat transfer applications

Lee, S. W. *et al. International Journal of Heat and Mass Transfer*, 2011, 54, (1–3), 433–438.

Nanofluids are nanotechnology-based colloidal dispersions engineered by stably suspending nanoparticles. Transmission electron microscopy and scanning electron microscope images are acquired to characterize the shape and size of SiC nanoparticles, because the properties of the nanofluids depend on the morphologies of nanoparticles. The dispersion behaviour for SiC/deionized water (DIW) nanofluids were investigated under different pH values and characterized with the zeta potential values. The isoelectric point of SiC/DIW nanofluid was identified in terms of colloidal stability. Then their viscosity and thermal conductivity were investigated as a function of volume fraction to evaluate SiC/DIW nanofluids' potential to function as more effective working fluids in heat transfer applications.

11/02700 Investigation on heat transfer properties of slurry of stabilized paraffin during a melting process

Royon, L. and Guiffant, G. *Energy Conversion and Management*, 2011, 52, (2), 1073–1076.

This paper is presented in the framework of the increasing interest for the use of latent heat transfer slurries for cooling processes. Paraffin serves as a latent heat storage material and a polymer network acts as the supporting material. The phase change material melts around 7 °C with a latent heat of fusion of 115 kJ/kg. A special experimental device is realized which permits the recording of the temperature in a single slurry undergoing a phase change in an agitated bath. Analysis of data permits to develop a phenomenological correlation adapted to the millimetric dimension of the slurry, leading to an estimation of the melting phase change time duration of a particle as a function of the main parameters of the problem.

11/02701 Localisation of deposited filling gases (CO_2) in cryogenic thermal insulation materials using neutron radiography

Geisler, G. *et al. Cryogenics*, 2011, 51, (3), 150–153.

The local distribution of deposited filling gases (CO_2) within a sample consisting of a packed bed of approximately 1 μm-sized solid glass spheres exposed to a temperature gradient at cryogenic temperatures was investigated by neutron radiography measurements. This local distribution is useful for the understanding of the degradation of the thermal conductivity in cryogenic thermal insulations and the technique of deposition–evacuation (cryoevacuation). As neutron radiography is expected to be sensitive to the CO_2-distribution, a special sample cell was designed which allows establishing a typical cryogenic temperature gradient (77–293 K). The two-dimensionally resolved transmission of the neutron flux by the cell reveals that all CO_2 is deposited preferentially at and close to the cold wall. The form of the spatial CO_2-distribution is not affected by the total amount of CO_2 injected into the sample.

11/02702 Model for transient behavior of pulse tube cryocooler

Grossman, G. *et al. Cryogenics*, 2011, 51, (3), 124–131.

This article describes an investigation of the transient behaviour of a small (2.0 W at 85 K) pulse tube cryocooler operating at 120 Hz with an average pressure of 3.5 MPa, capable of relatively fast cool-down from ambient to about 60 K. In a series of experiments, the cold end temperature was measured as a function of time in a complete cool-down and subsequent warm-up cycle, with no heat load and different quantities of excess mass at the cold end. A transient heat transfer model was developed, that considers the effects of the cooling power extracted at the cold end and that of the heat gain at the warm end on the cool-down time. The heat gain factor was calculated from warm-up data, and found to be approximately the same for all experiments. Using the same model with cool-down data enables a determination of both the gross and net cooling power as functions of time, but more importantly – as functions of the cold end temperature. An expression was derived for the cold end temperature as a function of time for any amount of excess mass, including zero. The cool-down time of the 'lean' cryocooler (with no excess mass) was found to be less than 50 s. This cool-down/warm-up method for evaluating the cooling power of a cryocooler seems simpler than steady-state experiments with a heater simulating load at the cold end. Use of the heat transfer model with data from one or two good experiments conducted in the above manner, can yield both the gross and net cooling powers of a cryocooler as functions of the cold end temperature, and allow the determination of cool-down time with any amount of excess thermal mass. While the net cooling power during cool-down differs somewhat from that under steady-state operation, the former can serve as a good measure for the latter.

11/02703 Modeling of horizontal geoexchange systems for building heating and permafrost stabilization

Fontaine, P.-O. *et al. Geothermics*, 2011, 40, (3), 211–220.

The authors present a new analytical model based on the finite line source that extends the steady state results for parallel horizontal pipes to the transient case and for any desired horizontal pipe layout. The analytical model is validated, when there is no freezing/thawing, by a three-dimensional finite element numerical model. When the phase change is accounted for in the numerical model, the analytical model still provides good approximation to the ground temperature during the heating season and the heat extracted by the ground heat exchanger. However, summer ground temperature and thaw depth are overestimated by the analytical model. A case study for a typical building in Kuujjuaq (northern Canada) area is analysed. The ground heat exchanger layout follows a spiral pattern characterized by three parameters: length *L*, depth *D*, and spacing *S*. The influence of each parameter on the amount of heat extracted from the ground and on the ground temperature at a control point is assessed. The results show that increasing depth *D* favours keeping the ground frozen at this depth and increases the amount of heat that may be extracted. Conversely, increasing *S* and/or *L* is beneficial for the amount of heat extracted, but it enhances the risk of thawing around the pipes. The model and case study provides useful ground heat exchanger design guidelines in cold regions for the double purpose of ground freezing and heat extraction.

11/02704 Morphology, structure and thermal stability of microencapsulated phase change material with copolymer shell

Li, W. *et al. Energy*, 2011, 36, (2), 785–791.

A series of microencapsulated phase change materials (MicroPCMs) with *n*-octadecane as core were successfully fabricated by suspension-like polymerization. The influence of initiator type and polymerization temperature on MicroPCMs were investigated systemically. The morphology of these microcapsules with different copolymer shells and various phase changing material (PCM) contents were observed by scanning electron microscopy (SEM). In addition, the core-shell structure and the shell thickness of microcapsules were also characterized by SEM. Thermal gravimetric analysis (TGA) curves indicate that the effects of different copolymer shell and various PCM contents on thermal stability of MicroPCMs were insignificant. Besides, SEM micrographs show that all of the MicroPCMs with various PCM contents remained intact after heat treatment at 200 °C for 30 min, however, all of the heat-treated MicroPCMs had no enthalpy as demonstrated by differential scanning calorimetry (DSC) curves. From above results, the weight loss of MicroPCMs may be caused by the penetration of decomposed gas of *n*-octadecane through the intact shells.

11/02705 Particle size effect on heat transfer performance in an oscillating heat pipe

Ji, Y. *et al. Experimental Thermal and Fluid Science*, 2011, 35, (4), 724–727.

The effect of Al_2O_3 particles on the heat transfer performance of an oscillating heat pipe (OHP) was investigated experimentally. Water was used as the base fluid for the OHP. Four size particles with average diameters of 50 nm, 80 nm, 2.2 μm, and 20 μm were studied, respectively. Experimental results show that the Al_2O_3 particles added in the OHP significantly affect the heat transfer performance and it depends on the particle size. When the OHP was charged with water and 80 nm Al_2O_3 particles, the OHP can achieve the best heat transfer performance among four particles investigated herein. In addition, it is found that all particles added in the OHP can improve the startup performance of the OHP even with 20 μm Al_2O_3 particles.

11/02706 Performance of PV-Trombe wall in winter correlated with south façade design

Sun, W. *et al. Applied Energy*, 2011, 88, (1), 224–231.

PV-Trombe wall (PVTW) is a novel version of Trombe-wall. Photovoltaic cells on the cover glazing of the PVTW can convert solar radiation into electricity and heat simultaneously. A window on the south façade can also introduce solar heat into the room in the winter season. Experiment has been conducted to study the temperature field of a building with both southern facing window and the PVTW. A dynamic numerical model is developed for the simulation of the whole building system. The temperature of the indoor air is found to be vertically stratified from the measurement. The nodal model is adopted to calculate the temperature profile in the room. The simulation results are in good agreement with the experimental data. The different south façade designs affect the thermal efficiency of the PVTW significantly from the numerical simulation. With a southern facing window, the thermal efficiency of the PVTW is reduced by 27% relatively. The increase of PV coverage on the glazing can reduce the thermal efficiency of the TW by up to 17%. By taking account of electric conversion, the total efficiency of solar utilization is reduced by 5% at most while the glazing is fully covered with PV cells. The electric conversion efficiency of the PVTW achieves 11.6%, and is slightly affected by south façade designs.

11/02707 Preparation, thermal properties and thermal reliability of microencapsulated *n*-eicosane as novel phase change material for thermal energy storage

Alkan, C. *et al. Energy Conversion and Management*, 2011, 52, (1), 687–692.

This study deals with preparation, characterization, thermal properties and thermal reliability of *n*-eicosane microcapsules as novel phase change material (PCM) for thermal energy storage. The microcapsulated PCMs were prepared by coating *n*-eicosane with polymethylmethacrylate (PMMA) shell. Fourier transform infrared (FT-IR), scanning electron microscope (SEM) and particle size distribution (PSD) analysis were used to characterize the PMMA/eicosane microcapsules as microcapsulated PCMs. The PSD analysis indicated that the average diameter of microcapsules was found to be 0.70 μm under the stirring speed of 2000 rpm. Thermal properties and thermal reliability of the microcapsules were determined using differential scanning calorimetry (DSC) and thermo gravimetric analysis (TGA) methods. From DSC analysis, the melting and freezing temperatures and the latent heats of the microcapsules were measured as 35.2 and 34.9 °C, 84.2 and –87.5 J/g, respectively. TGA analysis indicated that PMMA/eicosane microcapsules degrade in three steps at considerably high temperatures. Accelerated thermal cycling tests have been also applied to show the thermal reliability of the microcapsules. All results showed that thermal properties make the PMMA/eicosane microcapsules potential PCM for thermal energy storage.

11/02708 Refrigerant injection for heat pumping/air conditioning systems: literature review and challenges discussions

Xu, X. *et al. International Journal of Refrigeration*, 2011, 34, (2), 402–415.

This paper reviews the major research on refrigerant injection techniques in detail. Liquid and vapour refrigerant injection techniques are discussed and compared. The current research on refrigerant injection techniques falls into two categories: system level research and component level research. The system level research is focused on low ambient temperature heating, heat pump water heating, high ambient temperature cooling, cycle comparison, and control strategy development. Internal heat exchanger and flash tank cycles are the two typical cycles for refrigerant injection. These two cycles are discussed and compared in detail. The component level research is focused on employing different types of compressors, variable speed compressors, the injection process, and the flash tank. Different types of compressors employing refrigerant injection are presented. Based on the literature study, the potential future research directions are presented and discussed. The flash tank cycle control strategy and refrigerant charge management strategy are worth further research efforts. Compressor design can be improved in order to optimize the performance with refrigerant injection. The appropriate design of flash tanks plays a vital role in achieving appropriate two-phase flow patterns in the flash tank. Computational fluid dynamics modelling can be a useful tool to facilitate the design of the flash tank.

11/02709 Reliability and availability modelling of combined heat and power (CHP) systems

Haghifam, M. R. and Manbachi, M. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 385–393.

Many subsystems are involved in the reliability modelling of combined heat and power (CHP) systems, but in most studies these subsystems have not been classified and in many cases have been considered separately. Furthermore, calculating the reliability from the generation point to the consumer has not yet been studied. The authors classify combined heat and power subsystems and model their reliability, availability and mean-time-to-failure indices based on interactions between subsystems from the generation site to consumer delivery. The proposed CHP reliability and availability model is based on the state space and the continuous Markov method with electricity-generation, fuel-distribution and heat-generation subsystems. The effects of fuel- and water-distribution networks at the CHP site and the hot-water-distribution network on the consumer-utility reliability of CHP systems were fully assessed in an applicable case study. Additionally, the authors present a sensitivity analysis for island, standby and parallel operational modes of CHP systems. The results from the case study prove that improving the gas-distribution network, the network delivering hot water to the consumers and the water-delivery network to the CHP, in addition to optimizing the failure and repair rates of CHP systems, have considerable effects on the reliability improvement of the complete integrated system and have major roles in technical and economic feasibility studies of CHP systems.

11/02710 Rheology and flow characteristic of urban untreated sewage for cooling and heating source

Wu, X. *et al. Experimental Thermal and Fluid Science*, 2011, 35, (4), 612–617.

Urban untreated sewage is a kind of excellent cooling and heating source. The rheology and flow characteristic of sewage is the basis of the application of sewage cooling and heating source system. They are studied based on the theoretical assumption of single flow model, principle of tube-type rheometer, and field experiments. The rheological basic equations and flow characteristic of urban untreated sewage are developed. The results of research indicate that sewage has the characteristic of non-Newtonian power-law. The rheological basic equation is $\tau = 0.0031\gamma^{0.92}$. The distance coefficient of drag in turbulence of sewage in circle pipe is $\lambda_t = 0.186(\mathrm{Re}')^{-0.208}$. The equations of velocity distribution of sewage are, respectively, $v^+ = 2.5 \ln y^+ + 5.7$, $v^+ = 5.11 \ln y^+ - 3.22$, and $v^+ = y^+$ in turbulence, intermediate, and laminar current zone in circle pipe. Those can be used to instruct engineering application, design, analysis, and farther research of the system.

11/02711 Swimming pools as heat sinks for air conditioners: model design and experimental validation for natural thermal behavior of the pool

Woolley, J. *et al. Building and Environment*, 2011, 46, (1), 187–195.

Swimming pools as thermal sinks for air conditioners could save approximately 40% on peak cooling power and 30% of overall cooling energy, compared to standard residential air conditioning. Heat dissipation from pools in semi-arid climates with large diurnal temperature shifts is such that pool heating and space cooling may occur concurrently; in which case heat rejected from cooling equipment could directly displace pool heating energy, while also improving space cooling efficiency. The performance of such a system relies on the natural temperature regulation of swimming pools governed by evaporative and convective heat exchange with the air, radiative heat exchange with the sky, and conductive heat exchange with the ground. This paper describes and validates a model that uses meteorological data to accurately predict the hourly temperature of a swimming pool to within 1.1 °C maximum error over the period of observation. A thorough review of literature guided the selection of the most appropriate set of equations to describe the natural mass and energy exchange between a swimming pool and the environment. Monitoring of a pool in Davis, California, was used to confirm the resulting simulations. Comparison of predicted and observed pool temperature for all hours over a 56-day experimental period shows an *R*-squared relatedness of 0.967.

11/02712 The effect of a reflective underlay on the global thermal behaviour of pitched roofs

Roels, S. and Deurinck, M. *Building and Environment*, 2011, 46, (1), 134–143.

The influence of the emissivity of a roof underlay on the global thermal behaviour of sloped roofs is investigated. Five well-insulated pitched roofs have been constructed in a test building. The five roofs have a south-west and north-east-oriented pitch and differ in long wave emissivity of the underlay. All roofs are equipped with thermocouples and heat fluxes sensors to evaluate the thermal response of the roofs to the climatic conditions. Both summer and winter conditions have been measured. In addition to the *in situ* evaluation, a laboratory experiment was set-up to evaluate the influence of the emissivity of the underlay on the summer behaviour of a sloped roof under fixed boundary conditions. With thermocouples and heat flux sensors at different heights in the roof the effect of the reflective foil on the heat gain to the inside could be evaluated. The measured data are compared with a simple numerical model that accounts for the buoyancy effects in the ventilated cavity between tiles and underlay. Laboratory experiments and simulations revealed that a low emissivity of the underlay decreases the heat gain to the indoor environment, but that due to the thermal stack flow in the air cavity underneath the tiles, the advantage of a reflective foil mainly plays a role in the bottom part of the roof. In the *in situ* measurements it was found that workmanship, airtightness and wind and thermal stack effects are much more important and disturb the possible benefits of using a reflective underlay.

11/02713 Thermal performance of caprylic acid/1-dodecanol eutectic mixture as phase change material (PCM)

Zuo, J. *et al. Energy and Buildings*, 2011, 43, (1), 207–210.

Differential scanning calorimetry is used to investigate the thermal properties of caprylic acid, 1-dodecanol and their binary system. The experimental results show that the caprylic acid/1-dodecanol binary system presents eutectic point. The eutectic melting temperature (T_{em}) is 6.52 °C, and the latent heat of melting of eutectic mixture (ΔH_{em}) is 171.06 J g^{-1}. The corresponding mass fraction of 1-dodecanol in eutectic mixture is 30%. The eutectic melting temperature and the latent heat of phase change of eutectic mixture have not obvious variations after 60 and 120 thermal cycles, which proves that the eutectic mixture has good thermal stability.

11/02714 Thermodynamic analysis of a hybrid geothermal heat pump system

Lubis, L. I. *et al. Geothermics*, 2011, 40, (3), 233–238.

A thermodynamic analysis of a hybrid geothermal heat pump system is carried out. Mass, energy, and exergy balances are applied to the system, which has a cooling tower as a heat rejection unit, and system performance is evaluated in terms of coefficient of performance and exergy efficiency. The heating coefficient of performance for the overall system is found to be 5.34, while the corresponding exergy efficiency is 63.4%. The effect of ambient temperature on the exergy destruction and exergy efficiency is investigated for the system components. The results indicate that the performance of hybrid geothermal heat pump systems is superior to air-source heat pumps.

11/02715 Thermoeconomic optimization and exergy analysis of CO_2/NH_3 cascade refrigeration systems

Rezayan, O. and Behbahaninia, A. *Energy*, 2011, 36, (2), 888–895.

In this paper, thermoeconomic optimization and exergy analysis are applied to a CO_2/NH_3 cascade refrigeration cycle. Cooling capacity, ambient temperature and cold space temperature are constraints of the optimization procedure. Four parameters including condensing temperature of ammonia, evaporating temperature of carbon dioxide, condensing temperature of carbon dioxide and temperature difference in the cascade condenser are chosen as decision variables. The objective function is the total annual cost of the system which includes costs of input exergy to the system and annualized capital cost of the system. Input exergy to the system is the electricity consumption of compressors and fans, and the capital cost includes purchase costs of components. Results show that, optimum values of decision variables may be found by trade-off between the input exergy cost and capital cost. Results of the exergy analysis for each of the system components in the optimum state are also given.

11/02716 Thermoeconomic optimization of an ice thermal storage system for gas turbine inlet cooling

Sanaye, S. *et al. Energy*, 2011, 36, (2), 1057–1067.

The gas turbine power output and efficiency decrease with increasing ambient temperature. With compressor inlet air cooling, the air density and mass flow rate as well as the gas turbine net power output increase. The inlet cooling techniques include vapour or absorption refrigeration systems, evaporative cooling systems and thermal energy storage (TES) systems. In this paper the thermoeconomic analysis of ice (latent) thermal energy storage system for gas turbine inlet cooling application was performed. The optimum values of system design parameters were obtained using genetic algorithm optimization technique. The objective function included the capital and operational costs of the gas turbine, vapour compression refrigeration system, without (objective function I) and with (objective function II) corresponding cost due to the system exergy destruction. For gas turbines with net power output in the range of 25–100 MW, the inlet air cooling using a TES system increased the power output in the range of 3.9–25.7%, increased the efficiency in the range 2.1–5.2%, while increased the payback period from about 4 to 7.7 years.

11/02717 Wall/roof thermal performance differences between air-conditioned and non air-conditioned rooms

Barrios, G. *et al. Energy and Buildings*, 2011, 43, (1), 219–223.

A one-dimensional heat transfer model for periodic outdoor conditions is presented and used to evaluate the thermal performance of a monolayered and multilayered envelope wall/roof in an air-conditioned and in a non-air-conditioned room. Three materials are tested for a monolayered wall/roof: high density concrete (HDC), aerated concrete (AeC), and expanded polystyrene foam (EPS). Three multilayered walls/roofs of width 0.10 m composed of a sheet of 0.02 m of EPS and the rest of HDC are considered. The EPS can be on the outside, middle or inside of the wall/roof. The main conclusion is that an appropriate wall/roof for an air-conditioned room may not be suitable for a non air-conditioned one. For the monolayered wall/roof and conditions under study, it is found that in an air-conditioned room the most important physical property of the wall/roof is its thermal conductivity, which has to be as small as possible, while for the non-air-conditioned room the most important physical property is the thermal diffusivity, which also has to be as small as possible. In this case the position of the insulation in a multilayered wall/roof is important.

11 ENGINES

Power generation and propulsion, electrical vehicles

11/02718 An artificial immune system approach for fault detection in the stator and rotor circuits of induction machines

Chilengue, Z. *et al. Electric Power Systems Research*, 2011, 81, (1), 158–169.

In this paper, an artificial immune system approach to the detection and diagnosis of faults in the stator and rotor circuits of an induction machine is presented. The proposed technique requires the measurement of two stator currents to compute their $\alpha\beta$ representation before and after a fault condition. It is verified that for different faults, different patterns are generated by the vector $\alpha\beta$ representation, helping to construct a characteristic image of the operating condition of the induction machine. A pattern recognition algorithm inspired by how the immune system operates throughout the body is proposed to identify and classify the fault condition. According to the proposed methodology, there is no need to know the details of machine operation in a certain regime and all phenomena and effects resulting from the machine operating in this regime are taken into account. Several experimental results obtained on 2.2 kW and 3.2 kW three-phase induction machines are presented and discussed to validate the methodology, verifying its good performance in preventive fault detection.

11/02719 Application of artificial neural networks to micro gas turbines

Bartolini, C. M. *et al. Energy Conversion and Management*, 2011, 52, (1), 781–788.

In this work, artificial neural networks (ANNs) were applied to describe the performance of a micro gas turbine (MGT). In particular, they were used (i) to complete performance diagrams for unavailable experimental data; (ii) to assess the influence of ambient parameters on performance; and (iii) to analyse and predict emissions of pollutants in the exhausts. The experimental data used to feed the ANNs were acquired from a manufacturer's test bed. Though large, the data set did not cover the whole working range of the turbine; ANNs and an artificial neural fuzzy interference system (ANFIS) were therefore applied to fill information gaps. The results of this investigation were also used for sensitivity analysis of the machine's behaviour in different ambient conditions. ANNs can effectively evaluate both MGT performance and emissions in real installations in any climate, the worst R^2 in the validation set being 0.9962.

11/02720 Effect of hydrogen addition on lean burn performance of a spark-ignited gasoline engine at 800 rpm and low loads

Ji, C. and Wang, S. *Fuel*, 2011, 90, (3), 1301–1304.

To reduce the fuel consumption and emissions of spark-ignited (SI) engines, hydrogen enrichment was used to improve the performance of a lean burn SI engine operating at low speed and load conditions. A hydrogen port-injection system was mounted on the intake manifolds to introduce hydrogen into the intake ports sequentially while keeping the original gasoline injection system unchanged. A hybrid electronic control unit (HECU) was adopted to control injection timings and durations of gasoline and hydrogen, accomplishing four excess air ratios of 1.00, 1.18, 1.43 and 1.67 and three hydrogen volume fractions in the intake of 3%, 5%, 8%. The experimental results showed that engine brake thermal efficiency and torque output were increased, combustion durations were shortened, cyclic variation and HC emissions were reduced, but NO_x emissions were increased with the increase of hydrogen addition. CO emission was also reduced under lean conditions with hydrogen enrichment.

11/02721 Effect of various inlet air cooling methods on gas turbine performance

Farzaneh-Gord, M. and Deymi-Dashtebayaz, M. *Energy*, 2011, 36, (2), 1196–1205.

Turbine air inlet cooling is one of many available commercial methods to improve the efficiency of an existing gas turbine. The method has various configurations which could be utilized for almost all installed gas turbines. This paper presents a comparison between two commons and one novel inlet air cooling method using turbo-expanders to improve performance of a gas turbine located at the Khangiran refinery in Iran. These methods have been applied to one of the refinery gas turbines located at the Khangiran refinery in Iran. Two common air cooling methods use evaporative media or a mechanical chiller. The idea behind the novel method is to utilize the potential cooling and power capacity of the refinery natural gas pressure drop station by replacing throttling valves with a turbo-expander. The study is part of a comprehensive program with the goal of enhancing gas turbine performance at the Khangiran gas refinery. Based on the results, it is found that using turbo-expanders is the most economically feasible option and so is recommended to be utilized for improving gas turbine performance at the Khangiran refinery.

11/02722 Influence of metallic based fuel additives on performance and exhaust emissions of diesel engine

Keskin, A. *et al. Energy Conversion and Management*, 2011, 52, (1), 60–65.

In this experimental study, influence of the metallic-based additives on fuel consumption and exhaust emissions of diesel engine were investigated. The metallic-based additives were produced by synthesizing of resin acid (abietic acid) with MnO_2 or MgO. These additives were doped into diesel fuel at the rate of 8 μmol/l and 16 μmol/l for preparing test fuels. Both additives improved the properties of diesel fuel such as viscosity, flash point, cloud point and pour point. The fuels with and without additives were tested in a direct injection diesel engine at full load condition. Maximum reduction of specific fuel consumption was recorded as 4.16%. CO emission and smoke opacity decreased by 16.35% and by 29.82%, respectively. NO_x emission was measured higher and CO_2 emission was not changed considerably with the metallic-based additives.

11/02723 Investigation of forward flow distributed combustion for gas turbine application

Arghode, V. K. and Gupta, A. K. *Applied Energy*, 2011, 88, (1), 29–40.

A innovative advanced combustion design methodology for gas turbine applications is presented that focuses on the goal of zero emissions. The new design methodology is called colourless distributed combustion (CDC) and is significantly different from the currently used technique. In this paper, forward flow modes of CDC have been investigated for use in gas turbine combustors. The CDC provides significant improvement in pattern factor, reduced NO_x emissions and uniform thermal field in the entire combustion zone for it to be called an isothermal reactor. The basic requirement for a CDC is a carefully tailored mixture preparation through good mixing between the combustion air and product gases prior to rapid mixing with fuel so that the reactants are at much higher temperature to result in hot and diluted oxidant stream at temperatures that are high enough to autoignite the fuel and oxidant mixture. With desirable conditions, one can achieve spontaneous ignition of the fuel with distributed combustion reactions. Distributed reactions can also be achieved in premixed mode of operation with sufficient entrainment of burned gases and faster turbulent mixing between the reactants. In the present investigation, forward flow modes consisting of two non-premixed combustion modes and one premixed combustion mode have been examined that provide potential for CDC. In all the configurations the air injection port is positioned at the opposite side of the combustor exit, whereas the location of fuel injection ports is changed to give different configurations. Two combustion geometries resulting in thermal intensity of 5 MW/m^3-atm and 28 MW/m^3-atm are investigated. Increase in thermal intensity (lower combustion volume) presents many challenges such as lower residence time, lower recirculation of gases and effect of confinement on jet characteristics. The results are presented on the global flame signatures, exhaust emissions, and radical emissions using experiments and flowfield using numerical simulations. Ultra-low NO_x emissions are found for both the premixed and non-premixed combustion modes at the two thermal intensities investigated here. Almost colourless flames (no visible flame signatures) have been observed for the premixed combustion mode. The reaction zone is observed to be significantly different in the two non-premixed modes. Higher thermal intensity case resulted in lower recirculation of gases within the combustion chamber and higher CO levels, possibly due to lower associated residence time. The characteristics at the two thermal intensity combustors investigated here were found to be similar.

11/02724 Linear approximation of efficiency for a non-endoreversible cycle

Ladino-Luna, D. *Journal of the Energy Institute*, 2011, 84, (2), 61–65.

This paper analysed a non-endoreversible Curzon and Ahlborn cycle taking into account its time of adiabatic processes. Expressions of power output and ecological function with non-instantaneous adiabats were found, such as the corresponding linear approximation of efficiency for both maximum power output and maximum ecological function regimes.

11/02725 Modelling cycle to cycle variations in an SI engine with detailed chemical kinetics

Etheridge, J. *et al. Combustion and Flame*, 2011, 158, (1), 179–188.

This paper presents experimental results and a new computational model that investigate cycle to cycle variations (CCV) in a spark ignition (SI) engine. An established stochastic reactor model (SRM) previously used to examine homogeneous charge compression ignition (HCCI) combustion has been extended by spark initiation, flame propagation and flame termination sub-models in order to simulate combustion in SI engines. The model contains a detailed chemical mechanism but relatively short computation times are achieved. The flame front is assumed to be spherical and centred at the spark location, and a pent roof and piston bowl geometry are accounted for. The model is validated by simulating the pressure profile and emissions from an iso-octane fuelled single cylinder research engine that showed low CCV. The effects of key parameters are investigated. Experimental results that show cycle to cycle fluctuations in a four-cylinder naturally aspirated gasoline fuelled SI engine are presented. The model is then coupled with GT-Power, a one-dimensional engine simulation tool, which is used to simulate the breathing events during a multi-cycle simulation. This allows an investigation of the cyclic fluctuations in peak pressure. The source and magnitude of nitric oxide (NO) emissions produced by different cycles are then investigated. It was found that faster burning cycles result in increased NO emissions compared with cycles that have a slower rate of combustion and that more is produced in the early stages of combustion compared with later in the cycle. The majority of NO was produced via the thermal mechanism just after combustion begins.

11/02726 Spray and combustion characterization for internal combustion engines using optical measuring techniques – a review

Soid, S. N. and Zainal, Z. A. *Energy*, 2011, 36, (2), 724–741.

The number of studies on spray and combustion characteristics in internal combustion engines using optical techniques has rapidly increased in the past few years due to an increase in the number of alternative fuels and stricter emission standard regulations. This study investigates better ways of controlling the combustion process, thus ensuring optimum performance and minimum emission levels produced during the combustion process. Alternative fuels such as compressed natural gas, biodiesel and hydrogen have been studied by many researchers due to their relative low environmental impact. Meanwhile, for conventional fuels such as gasoline and diesel, studies have focused on spray characteristics to provide better air–fuel mixtures in order to produce a cleaner combustion process. Few experimental works have investigated the effects of modifications to the injector itself, for example, varying the injection rate, injection pressure, etc. In order to provide a better understanding of spray and combustion characteristics, researchers have studied macroscopic and microscopic parameters using optical techniques. This paper presents the significance of spray and combustion study with optical techniques that have been reported by previous researchers in order to provide in depth knowledge as assistance to readers interested in this research area.

11/02727 The impact of vehicle-to-grid on the distribution grid

Clement-Nyns, G. *et al. Electric Power Systems Research*, 2011, 81, (1), 185–192.

Plug-in hybrid electric vehicles (PHEVs) can be connected to the power grid. The power flow of this connection can be bidirectional, so vehicles can charge and discharge. This vehicle-to-grid option can aid to improve grid efficiency and reliability. A simulation covering an entire day is essential to obtain an accurate assessment of the impact of PHEVs. It is important to know when, statistically, vehicles are available for charging or discharging. In this work is shown that uncoordinated charging of PHEVs in distribution grid can lead to local grid problems. Therefore, coordinated charging and discharging is investigated and a voltage constraint is implemented. These vehicles can support the grid in terms of voltage control and congestion management. In that way, the distribution grid can handle more PHEVs without reinforcements. Distributed generation units are more common nowadays in the distribution grid with some of these generation units based on intermittent renewable resources. This paper shows that there could be a good combination with PHEVs as they can provide storage to take care of the excess of produced energy and use it for driving or release it into the grid at a later time. In that way, consumption and generation are more efficiently matched.

11/02728 Theoretical limits of scaling-down internal combustion engines

Sher, E. and Sher, I. *Chemical Engineering Science*, 2011, 66, (3), 260–267.

Small-scale energy conversion devices are being developed for a variety of applications; these include propulsion units for micro-aerial vehicles (MAV). The high specific energy of hydrocarbon and hydrogen fuels, as compared to other energy storing means, like batteries, elastic elements, flywheels and pneumatics, appears to be an important advantage, and favours the internal combustion engine (ICE) as a candidate. In addition, the specific power (power per mass of unit) of the ICE seems to be much higher than that of other candidates. However, micro ICE engines are not simply smaller versions of full-size engines. Physical processes such as combustion and gas exchange, are performed in regimes different from those that occur in full-size engines. Consequently, engine design principles are different at a fundamental level and have to be re-considered before they are applied to micro-engines. When a spark-ignition (SI) cycle is considered, part of the energy that is released during combustion is used to heat up the mixture in the quenching volume, and therefore the flame-zone temperature is lower and in some cases can theoretically fall below the self-sustained combustion temperature. Flame quenching thus seems to limit the minimum dimensions of a SI engine. This limit becomes irrelevant when a homogeneous-charge compression-ignition (HCCI) cycle is considered. In this case friction losses and charge leakage through the cylinder-piston gap become dominant, constrain the engine size and impose minimum engine speed limits. In the present work a phenomenological model has been developed to consider the relevant processes inside the cylinder of a homogeneous-charge compression-ignition (HCCI) engine. An approximated analytical solution is proposed to yield the lower possible limits of scaling-down HCCI cycle engines. The authors present a simple algebraic equation that shows the inter-relationships between the pertinent parameters and constitutes the lower possible miniaturization limits of IC engines.

11/02729 Toxicological characterization of diesel engine emissions using biodiesel and a closed soot filter

Kooter, I. M. *et al. Atmospheric Environment*, 2011, 45, (8), 1574–1580.
This study was designed to determine the toxicity (oxidative stress, cytotoxicity, genotoxicity) in extracts of combustion aerosols. A typical Euro III heavy truck engine was tested over the European transient cycle with three different fuels: conventional diesel EN590, biodiesel EN14214 as B100 and blends with conventional diesel (B5, B10, and B20) and pure plant oil DIN51605 (PPO). In addition application of a (wall flow) diesel particulate filter (DPF) with conventional diesel EN590 was tested. The use of B100 or PPO as a fuel or the DPF reduced particulate matter (PM) mass and numbers over 80%. Similarly, significant reduction in the emission of chemical constituents (EC 90%, (oxy)-PAH 70%) were achieved. No significant changes in nitro-PAH were observed. The use of B100 or PPO led to a NO_x increase of about 30%, and no increase for DPF application. The effects of B100, PPO and the DPF on the biological test results vary strongly from positive to negative depending on the biological end point. The oxidative potential, measured via the DTT assay, of the B100 and PPO or DPF emissions is reduced by 95%. The cytotoxicity is increased for B100 by 200%. The measured mutagenicity, using the Ames assay test with TA98 and YG1024 strains of *Salmonella typhimurium* indicate a dose response for the nitroarene sensitive YG1024 strain for B100 and PPO (fold induction: 1.6). In summary B100 and PPO have good potential for the use as a second generation biofuel resulting in lower PM mass, similar to application of a DPF, but caution should be made due to potential increased toxicity. Besides regulation via mass, the biological reactivity of exhaust emissions of new (bio)fuels and application of new technologies, needs attention. The different responses of different biological tests as well as differences in results between test laboratories underline the need for harmonization of test methods and international cooperation.

Hybrid engine systems

11/02730 A combustion model for IC engine combustion simulations with multi-component fuels

Ra, Y. and Reitz, R. D. *Combustion and Flame*, 2011, 158, (1), 69–90.
Reduced chemical kinetic mechanisms for the oxidation of representative surrogate components of a typical multi-component automotive fuel have been developed and applied to model internal combustion engines. Starting from an existing reduced mechanism for primary reference fuel (PRF) oxidation, further improvement was made by including additional reactions and by optimizing reaction rate constants of selected reactions. Using a similar approach to that used to develop the reduced PRF mechanism, reduced mechanisms for the oxidation of *n*-tetradecane, toluene, cyclohexane, dimethyl ether (DME), ethanol, and methyl butanoate (MB) were built and combined with the PRF mechanism to form a multi-surrogate fuel chemistry (MultiChem) mechanism. The final version of the MultiChem mechanism consists of 113 species and 487 reactions. Validation of the present MultiChem mechanism was performed with ignition delay time measurements from shock tube tests and predictions by comprehensive mechanisms available in the literature. A combustion model was developed to simulate engine combustion with multi-component fuels using the present MultiChem mechanism, and the model was applied to simulate HCCI and DI engine combustion. The results show that the present multi-component combustion model gives reliable performance for combustion predictions, as well as computational efficiency improvements through the use of reduced mechanism for multi-dimensional CFD simulations.

11/02731 Characterization and effect of using cotton methyl ester as fuel in a LHR diesel engine

Hazar, H. *et al. Energy Conversion and Management*, 2011, 52, (1), 258–263.
In the present study, surfaces of cylinder head, piston, exhaust and inlet valve of a four-stroke, direct injection, single cylinder diesel engine were coated with molybdenum (Mo) by plasma spray method. Thus, thermal barrier characteristic was brought to these parts. Variances in performance and emission values of cotton methyl ester and two-dimensional fuel mixtures were studied in the ceramic coated and uncoated engines under the same running conditions. Performance (6.0% for specific fuel consumption) and emission values (up to 18.0% for CO, 8.0% for smoke density) of the test fuel were improved in the coated engine compared with the uncoated engine. NO_x increase (4.5%) with the increased temperatures expected in the coated engine.

11/02732 Combining hybrid cars and synthetic fuels with electricity generation and carbon capture and storage

van Vliet, O. *et al. Energy Policy*, 2011, 39, (1), 248–268.
The authors examined the co-evolution of the transportation, and electricity and heat generation sectors in the Netherlands until 2040 using a MARKAL bottom-up cost optimization model. All scenario variants investigated indicate a switch away from crude oil-based diesel and petrol for transportation. Lowest overall CO_2 abatement cost is achieved by accommodating transportation first and using relatively expensive options for emissions reduction in electricity generation if needed. Biomass and carbon capture and storage (CCS) are used to full potential. Transportation CO_2 emissions are reduced by switching to ethanol or bio-based synthetic fuels combined with CCS, and series hybrid cars if needed. Depending on the availability of biomass and carbon storage capacity, electricity is produced from biomass, coal with CCS, or wind complemented with natural gas. Indirect greenhouse gas emissions rise to 34–54% of national emissions in 2040. The difference in annual investment required between the scenario variants with and without CO_2 emissions reductions of 68% by 2040 is €4–7 billion/year, or 0.5–1.2% of projected GDP. Investment costs are mostly determined by the cost of cars and electricity generation capacity. The authors observe competition for limited biomass supply and CO_2 storage capacity between the transportation and power sectors.

11/02733 Combustion and emission characteristics of blends of diesel fuel and methanol-to-diesel

Guo, Z. *et al. Fuel*, 2011, 90, (3), 1305–1308.
Methanol-to-diesel (MTD) means a synthetic diesel fuel, its raw material is methanol. And it is a liquid alcohol ether mixture with appropriate amount of additives, which can be blended with diesel fuel at various levels. It was synthesized by methanol with 1,2-epoxypropane and epoxyethane using modified calcined Mg/Al hydroxides as catalysts. The test and study on the physical properties of MTD and the fuel consumption and emissions of diesel engine using the mixed MTD and diesel fuel have been performed. The results indicates that there was no significant difference in the power values of diesel and the blend fuels while fuel consumption increasing around 14%, and of much lower emissions of exhaust. When using the diesel fuel mixed with 20–30% of MTD. The conclusion is that MTD is a cheap and clean low power loss additive fuel for diesel engines.

11/02734 Control strategy of hydraulic/electric synergy system in heavy hybrid vehicles

Hui, S. *et al. Energy Conversion and Management*, 2011, 52, (1), 668–674.
Energy consumption and exhaust emissions of hybrid vehicles strongly depend on the energy storage source and the applied control strategy. Heavy vehicles have the characteristics of frequent starts/stops and significant amounts of braking energy, which needs to find a more efficient way to store and use the high power flow. A novel parallel hybrid vehicles configuration consisting of hydraulic/electric synergy system is proposed to overcome the existing drawbacks of single energy storage source in heavy hybrid vehicles. A control strategy combining a logic threshold approach and key parameters optimization algorithm is developed to achieve acceptable vehicle performance while simultaneously maximizing engine fuel economy and maintaining the battery state of charge in its rational operation range at all times. The experimental and simulation results illustrate the potential of the proposed control strategy in terms of fuel economy and in keeping the deviations of SOC at high efficiency range.

11/02735 Determination of performance and combustion characteristics of a diesel engine fueled with canola and waste palm oil methyl esters

Ozsezen, A. N. and Canakci, M. *Energy Conversion and Management*, 2011, 52, (1), 108–116.
In this study, the performance, combustion and injection characteristics of a direct injection diesel engine have been investigated experimentally when it was fuelled with canola oil methyl ester (COME) and waste (frying) palm oil methyl ester (WPOME). In order to determine the performance and combustion characteristics, the experiments were conducted at constant engine speeds under the full load condition of the engine. The results indicated that when the test engine was fuelled

with WPOME or COME instead of petroleum based diesel fuel (PBDF), the brake power reduced by 4–5%, while the brake specific fuel consumption increased by 9–10%. On the other hand, methyl esters caused reductions in carbon monoxide (CO) by 59–67%, in unburned hydrocarbon (HC) by 17–26%, in carbon dioxide (CO_2) by 5–8%, and smoke opacity by 56–63%. However, both methyl esters produced more nitrogen oxides (NO_x) emissions by 11–22% compared with those of the PBDF over the speed range.

11/02736 Energy consumption and conservation in food retailing

Tassou, S. A. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 147–156.

The total annual CO_2 emissions associated with the energy consumption of the major retail food outlets in the UK amount to around 4.0 $MtCO_2$. The energy consumption and emissions from supermarkets varies widely and can depend on many factors such as the type and size of the store, business and merchandizing practices and refrigeration and environmental control systems used. This paper provides energy consumption data of a sample of 2570 retail food stores from a number of major retail food chains in the UK. The sample covers all major store categories from convenience stores to hypermarkets and includes approximately 30% of the total number of stores in the UK having a net sales area more than 280 m^2. The data show a wide variability of energy intensity even within stores of the same retail chain. A power law can be used to describe the variation of the average electrical energy intensity of the stores in the sample with sales area. If the electrical intensity of the stores above the average is reduced to the average by energy conservation measures, annual energy savings of the order of 10% or 840 GWh can be achieved representing 355,000 tonnes of annual reduction in CO_2 emissions. The paper also discusses the major energy consuming processes in retail food stores and identifies opportunities for energy savings.

11/02737 Experimental studies on fumigation of ethanol in a small capacity Diesel engine

Chauhan, B. S. *et al. Energy*, 2011, 36, (2), 1030–1038.

To diversify the mix of domestic energy resources and to reduce dependence on imported oil, ethanol is widely investigated for applying in combination with Diesel fuel to reduce pollutants, including smoke and NO_x. This study develops a fumigation system for introduction of ethanol in a small capacity diesel engine and to determine its effects on emission. Fumigation was achieved by using a constant volume carburettor. Different percentages of ethanol fumes with air were then introduced in the Diesel engine, under various load conditions. Ethanol is an oxygenated fuel and lead to smooth and efficient combustion. Atomization of ethanol also results in lower combustion temperature. During the present study, gaseous emission has been found to be decreasing with ethanol fumigation. Results from the experiment suggest that ethanol fumigation can be effectively employed in existing compression ignition engine to achieve substantial saving of the limited Diesel oil. Results show that fumigated Diesel engine exhibit better engine performance with lower NO_x, CO, CO_2 and exhaust temperature. Ethanol fumigation has resulted in increase of unburned hydrocarbon emission in the entire load range. Considering the parameters, the optimum percentage was found as 15% for ethanol fumigation.

11/02738 Theoretical performance limits of a syngas–diesel fueled compression ignition engine from second law analysis

Sahoo, B. B. *et al. Energy*, 2011, 36, (2), 760–769.

The present study is an attempt to investigate a syngas–diesel dual-fuelled diesel engine operation under varying load conditions from the second law point of view. The fuel type in dual fuel operation is achieved by varying the volumetric fractions of hydrogen (H_2) and carbon monoxide (CO) content in syngas. It is revealed that increasing the H_2 quantity of syngas increases the cumulative work availability and reduces the destroyed availability. This enhancement is due to a better combustion process and increased work output when a high amount of H_2 quantity is employed. At lower loads, the in-cylinder combustion temperatures are reduced in case of the dual fuel combustion. Hence, the destruction availability is increased due to poor combustion and reduced heat transfer availability losses. When the engine is operated beyond 40% load, the destroyed availability reduced due to higher combustion temperature and pressure. The increase in the both exhaust gas and cooling water availabilities are reflected in an increase in second law efficiency with increasing load. The dual fuel cumulative work availability is increased at higher loads and thus, the exergy efficiency is increased.

11/02739 Ultracapacitors for fuel saving in small size hybrid vehicles

Solero, L. *et al. Journal of Power Sources*, 2011, 196, (1), 587–595.

The main purpose of the paper is to describe a small size hybrid vehicle having ultracapacitors as on-board storage unit. The vehicle on-board main power supply is achieved by a genset being formed of a 250 cm^3 internal combustion engine and a permanent magnet synchronous electric generator, whereas 4 16V-500F ultracapacitors modules are connected in series in order to supply as well as to store the power peaks during respectively acceleration and braking vehicle modes of operation. The traction power is provided by a permanent magnet synchronous electric motor, whereas a distributed power electronic interface is in charge of all the required electronic conversions as well of controlling the operating conditions for each power unit. The paper discusses the implemented control strategy and shows experimental results on the modes of operation of both generation unit and storage unit.

Transport battery development

11/02740 A comprehensive overview of hybrid electric vehicle: Powertrain configurations, powertrain control techniques and electronic control units

Bayindir, K. Ç. *et al. Energy Conversion and Management*, 2011, 52, (2), 1305–1313.

The studies for hybrid electrical vehicle (HEV) have attracted considerable attention because of the necessity of developing alternative methods to generate energy for vehicles due to limited fuel based energy, global warming and exhaust emission limits in the last century. HEV incorporates internal composition engine, electric machines and power electronic equipments. In this study, overview of HEVs with a focus on hybrid configurations, energy management strategies and electronic control units are presented. Advantages and disadvantages of each configuration are clearly emphasized. The existing powertrain control techniques for HEVs are classified and comprehensively described. Electronic control units used in HEV configuration are also elaborated. The latest trends and technological challenges in the near future for HEVs are discussed.

11/02741 A film of porous carbon nanofibers that contain Sn/SnO$_x$ nanoparticles in the pores and its electrochemical performance as an anode material for lithium ion batteries

Zou, L. *et al. Carbon*, 2011, 49, (1), 89–95.

A film of porous carbon nanofibres that contain Sn/SnO_x nanoparticles in the pores has been prepared by an electrospinning process. The pores in the fibres and the abundant spaces between the fibres not only offer more interface for the reaction of the film and lithium ions, but also buffer the volumetric change of the whole film during cycling. The nanofibres consist of porous carbon with encapsulated Sn/SnO_x nanoparticles. The size of the particles encapsulated in the pores is smaller than the volume of the pores, thus providing buffering spaces for the volumetric change of tin during cycling. These features result in its good electrochemical performance that is 735 and 510 mAh g^{-1} in the 1st and 40th cycle, respectively. This film can be used as an electrode directly without any binder or conductive filler.

11/02742 A rechargeable lithium-ion battery module for underwater use

Pendergast, D. R. *et al. Journal of Power Sources*, 2011, 196, (2), 793–800.

Portable underwater electrical power is needed for many commercial, recreational and military applications. A battery system is currently not available to meet these needs, which was the aim of this project. Lithium-ion battery cells (Panasonic CGR18650E) were chosen, based on their high energy density and availability. To increase their voltage, eight battery cells were connected in series (‘sticks’) and protected by encapsulating them into a polycarbonate tube; and six sticks were housed inside a triangular aluminium case (module). Testing was performed to determine the consistency of individual cells, sticks and module and during discharge/charging cycles. The effect of ambient temperature (T_A) was determined by attaching thermocouples. In addition, voltage and current were measured and used to determine the heat generated within the battery cell and were compared to theory. From these data, a radial temperature profile was determined for two battery sticks in the battery module. Collapse pressure was determined and compared to theory. The Panasonic CGR18650E cells delivered 2291 mAh each over a wide range of T_A and discharge/charge rates. The theoretical and experimental data showed that the temperature within the battery sticks and modules did not rise above or below their operating temperature range (−20 and 60 °C), in agreement with the models. The tubes encapsulating the sticks withstood pressures down to 305 m of sea water (msw) which was predicted by modelling. The Panasonic CGR18650E cells, sticks and module demonstrated that they provided sufficient electrical power, reliably and safely to be used in the underwater environment (1800–2000 kPa, 305 msw) over a wide range T_A, including high power requirement systems like an active thermal protection system that keeps a diver comfortable in extreme temperature conditions. The concept developed here can be modified to meet specific power requirements by varying the number of cell in series to achieve the desired voltage, and the number of sticks in parallel to provide the current capacity required.

11/02743 Experimental investigation on the dynamic performance of a hybrid PEM fuel cell/battery system for lightweight electric vehicle application

Tang, Y. *et al. Applied Energy*, 2011, 88, (1), 68–76.

A hybrid system combining a 2 kW air-blowing proton exchange membrane fuel cell (PEMFC) stack and a lead–acid battery pack is developed for a lightweight cruising vehicle. The dynamic performances of this PEMFC system with and without the assistance of the batteries are systematically investigated in a series of laboratory and road tests. The stack current and voltage have timely dynamic responses to the load variations. Particularly, the current overshoot and voltage undershoot both happen during the step-up load tests. These phenomena are closely related to the charge double-layer effect and the mass transfer mechanisms such as the water and gas transport and distribution in the fuel cell. When the external load is beyond the range of the fuel cell system, the battery immediately participates in power output with a higher transient discharging current especially in the accelerating and climbing processes. The DC–DC converter exhibits a satisfying performance in adaptive modulation. It helps rectify the voltage output in a rigid manner and prevent the fuel cell system from being overloaded. The dynamic responses of other operating parameters such as the anodic operating pressure and the inlet and outlet temperatures are also investigated. The results show that such a hybrid system is able to dynamically satisfy the vehicular power demand.

11/02744 Highly reversible Co_3O_4/graphene hybrid anode for lithium rechargeable batteries

Kim, H. *et al. Carbon*, 2011, 49, (1), 326–332.

A Co_3O_4/graphene hybrid material was fabricated using a simple in situ reduction process and demonstrated as a highly reversible anode for lithium rechargeable batteries. The hybrid is composed of 5 nm size Co_3O_4 particles uniformly dispersed on graphene, as observed by transmission electron microscopy, atomic force microscopy, Raman spectroscopy and X-ray diffraction analysis. The Co_3O_4/graphene anode can deliver a capacity of more than 800 mA h g^{-1} reversibly at a 200 mA g^{-1} rate in the voltage range between 3.0 and 0.001 V. The high reversible capacity is retained at elevated current densities. At a current rate as high as 1000 mA g^{-1}, the Co_3O_4/graphene anode can deliver more than 550 mA h g^{-1}, which is significantly higher than the capacity of current commercial graphite anodes. The superior electrochemical performance of the Co_3O_4/graphene is attributed to its unique nanostructure, which intimately combines the conductive graphene network with uniformly dispersed nano Co_3O_4 particles.

11/02745 Hydrogen fuel cell hybrid vehicles (HFCHV) for Birmingham campus

Kendall, K. *et al. Journal of Power Sources*, 2011, 196, (1), 325–330.

The design of a campus mail delivery vehicle powered by 350 bar hydrogen feeding a 1.2 kW PEM fuel cell to charge a lead acid battery pack is described. Five vehicles supplied to the campus at the University of Birmingham to measure the performance and to evaluate relevance to fleet operations are discussed. It is shown that the performance is better than that of a standard diesel van in two drive cycles, one following an academic circuit around the campus, the other doing multiple mail delivery stops. The acceleration and drive cycle compliance are found to be adequate on campus and the efficiency is significantly better than the diesel. The need for extension of range and increase in power and acceleration to meet standard urban drive cycles is clearly demonstrated.

11/02746 Modeling the CO_2 emissions from battery electric vehicles given the power generation mixes of different countries

Doucette, R. T. and McCulloch, M. D. *Energy Policy*, 2011, 39, (2), 803–811.

With the number of vehicles on the world's roads expected to grow to 2.9 billion by 2050, steps must be taken to reduce the CO_2 emissions from transport. Battery electric vehicles (BEVs) can help achieve this. This study aimed to determine the CO_2 emissions stemming from BEV operation in different countries and to compare those CO_2 emissions to the emissions from similar vehicles based on internal combustion engines (ICEs). This study selected four ICE-based vehicles, and modelled BEVs based on the specifications of each of these vehicles. The modelled BEVs were run through a simulation to determine their energy consumption. Their energy consumption was combined with data on the CO_2 intensity of the power generation mix in different countries to reveal the emissions resulting from BEV operation. The CO_2 emissions from the BEVs were compared to the CO_2 emissions for their ICE-based counterparts. Among the results, it was shown that for China and India, and other countries with a similarly high CO_2 intensity, unless power generation becomes dramatically less CO_2 intensive, BEVs will not be able to deliver a meaningful decrease in CO_2 emissions and an increase in the penetration of BEVs could actually lead to higher CO_2 emissions.

11/02747 Plug-in hybrid electric vehicle charge pattern optimization for energy cost and battery longevity

Bashash, S. *et al. Journal of Power Sources*, 2011, 196, (1), 541–549.

This paper examines the problem of optimizing the charge pattern of a plug-in hybrid electric vehicle (PHEV), defined as the timing and rate with which the PHEV obtains electricity from the power grid. The optimization goal is to simultaneously minimize (i) the total cost of fuel and electricity and (ii) the total battery health degradation over a 24-h naturalistic drive cycle. The first objective is calculated for a previously developed stochastic optimal PHEV power management strategy, whereas the second objective is evaluated through an electrochemistry-based model of anode-side resistive film formation in lithium-ion batteries. The paper shows that these two objectives are conflicting, and trades them off using a non-dominated sorting genetic algorithm. As a result, a Pareto front of optimal charge patterns is obtained. The effects of electricity price and trip schedule on the optimal Pareto points and the PHEV charge patterns are analysed and discussed.

11/02748 Plug-in hybrid vehicle GHG impacts in California: integrating consumer-informed recharge profiles with an electricity-dispatch model

Axsen, J. *et al. Energy Policy*, 2011, 39, (3), 1617–1629.

This paper explores how plug-in hybrid vehicles (PHEVs) may reduce source-to-wheel greenhouse gas (GHG) emissions from passenger vehicles. The two primary advances are the incorporation of (1) explicit measures of consumer interest in and potential use of different types of PHEVs and (2) a model of the California electricity grid capable of differentiating hourly and seasonal GHG emissions by generation source. The authors constructed PHEV emissions scenarios to address inherent relationships between vehicle design, driving and recharging behaviours, seasonal and time-of-day variation in GHG-intensity of electricity, and total GHG emissions. A sample of 877 California new vehicle buyers provided data on driving, time of day recharge access, and PHEV design interests. The elicited data differed substantially from the assumptions used in previous analyses. The authors constructed electricity demand profiles scaled to a million PHEVs and entered them into an hourly California electricity supply model to simulate GHG emissions. Compared to conventional vehicles, consumer-designed PHEVs cut marginal (incremental) GHG emissions by more than one-third in current California energy scenarios and by one-quarter in future energy scenarios – reductions similar to those simulated for all-electric PHEV designs. Across the emissions scenarios, long-term GHG reductions depends on reducing the carbon intensity of the grid.

11/02749 Preliminary experimental evaluation of a four wheel motors, batteries plus ultracapacitors and series hybrid powertrain

Rambaldi, L. *et al. Applied Energy*, 2011, 88, (2), 442–448.

This paper reports the preliminary experimental evaluation of a four-wheel motors series hybrid prototype equipped with an internal combustion engine coupled to a generator and an energy recovery system (batteries plus ultracapacitors). The paper analyses global efficiency (energy dissipated to overcome the dissipative forces on energy dissipated in fuel), autonomy in electric configuration, and the efficiency of the regenerative braking system. The tests were carried out in a test cell equipped with a chassis dynamometer. The tests were performed according to the current regulated procedures. A constant speed test was performed in order to evaluate the autonomy of the vehicle in the electric configuration. The results show that the real tank to wheels efficiency is about 30% for HOST as a series hybrid and 79% for HOST as an electric vehicle.

11/02750 State-of-charge estimation of valve regulated lead acid battery based on multi-state unscented Kalman filter

Zhang, J. and Xia, C. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 472–476.

As a vital part of the battery-employed system, battery management system (BMS) must correctly estimate values descriptive of the battery's present operating condition. As is known to all, state-of-charge (SOC) is a key battery state for BMS to estimate. In this paper, based on unscented Kalman filter (UKF) theory and a comprehensive battery model, a novel SOC estimation method is proposed. A non-linear mapping process is involved to recursively calculate the system state variable, thus the errors caused by extended Kalman filter (EKF) can be effectively restrained; besides, compared with many simple battery models recently, the comprehensive model presented in this paper can track the operating performance of valve regulated lead acid (VRLA) battery more correctly. The whole estimation process is clearly given; then EKF and UKF are compared through experimental analysis; the results show that UKF method is superior to EKF method in SOC estimation for VRLA battery.

11/02751 The power capability of ultracapacitors and lithium batteries for electric and hybrid vehicle applications

Burke, A. and Burke, M. *Journal of Power Sources*, 2011, 196, (1), 514–522.

There is much confusion and uncertainty in the literature concerning the useable power capability of batteries and ultracapacitors (electrochemical capacitors) for various applications. Clarification of this confusion is one of the primary objectives of this paper. The three approaches most often applied to determine the power capability of devices are (1) matched impedance power, (2) the min/max method of the USABC, and (3) the pulse energy efficiency approach used at the University of California, Davis. It has been found that widely different power capability for batteries and ultracapacitors can be inferred using these approaches even when the resistance and open-circuit voltage are accurately known. In general, the values obtained using the energy efficiency method for EF = 90–95% are much lower than the other two methods which yield values corresponding to efficiencies of 70–75%. For plug-in hybrid and battery electric vehicle applications, the maximum useable power density for a lithium-ion battery can be higher than that corresponding to 95% efficiency because the peak power of the driveline is used less frequently and consequently charge/discharge efficiently is less important. For these applications, the useable power density of the batteries can be closer to the useable power density of ultracapacitors. In all cases, it is essential that a careful and appropriate measurement is made of the resistance of the devices and the comparisons of the useable power capability be made in a way appropriate for the application for which the devices are to be used.

11/02752 Willingness to pay for electric vehicles and their attributes

Hidrue, M. K. *et al. Resource and Energy Economics*, 2011, 33, (3), 686–705.

This article presents a stated preference study of electric vehicle choice using data from a national survey. A choice experiment was used where 3029 respondents were asked to choose between their preferred gasoline vehicle and two electric versions of that preferred vehicle. A latent class random utility model was used to estimate the willingness to pay for five electric vehicle attributes: driving range, charging time, fuel cost saving, pollution reduction, and performance. Driving range, fuel cost savings, and charging time led in importance to respondents. Individuals were willing to pay (WTP) from $35 to $75 for a mile of added driving range, with incremental WTP per mile decreasing at higher distances. They were WTP from $425 to $3250 per hour reduction in charging time (for a 50 mile charge). Respondents capitalized about 5 years of fuel saving into the purchase price of an electric vehicle. The model simulated a range of electric vehicle configurations and it was found that people with the highest values for electric vehicles were WTP a premium above their WTP for a gasoline vehicle that ranged from $6000 to $16,000 for electric vehicles with the most desirable attributes. At the same time, the results suggest that battery cost must drop significantly before electric vehicles will find a mass market without subsidy.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

11/02753 Application of advanced glazing and overhangs in residential buildings

Ebrahimpour, A. and Maerefat, M. *Energy Conversion and Management*, 2011, 52, (1), 212–219.

External shading affects the solar energy incident on a window and the transferred energy within the room through the window. In present study, the effect of advanced glazing and overhangs on the solar energy transmitted into or lost from the room through the fenestration areas have been evaluated for typical residential buildings in Tehran, using EnergyPlus software. It was found that appropriate overhangs or side fins in the south, west and east windows would lead to the optimal reduction of the annual energy transferred into the buildings and can have an energetic behaviour equivalent to high performance glazing. The results have been summarized in a table to simple selecting the best window with different glazings, overhangs and side fins based on energy rating.

11/02754 Composite sorbent of methanol ‘LiCl in mesoporous silica gel’ for adsorption cooling: dynamic optimization

Gordeeva, L. G. and Aristov, Y. I. *Energy*, 2011, 36, (2), 1273–1279.

A novel composite sorbent of methanol ‘LiCl in mesoporous silica gel’ has recently been proposed for adsorption cooling (AC). Its testing in a lab-scale adsorption chiller resulted in the specific cooling power of 210–290 W/kg and the cooling COP of 0.32–0.4. Although these values are rather encouraging, a room for their enhancement still exists. The aim of this paper was a dynamic optimization of the composite performance in AC cycles. Dynamics of methanol sorption on loose grains of the LiCl/silica composites was studied by a large temperature jump method under typical conditions of AC cycle. Effects of number of the sorbent layers, salt content, grain size and cycle boundary temperatures were studied. Physicochemical processes in the three-phase system (salt, solution, vapour) were shown to be quite complex and can strongly affect the dynamics of methanol adsorption/desorption. Several obstacles which can retard the sorption were analysed. Appropriate recommendations on improving the cycle dynamics, which concern optimal conversion degree, salt content and relative durations of adsorption and desorption phases, were made.

11/02755 Configuration and installation design of optical diagnostic systems on KSTAR

Na, H. K. *et al. Fusion Engineering and Design*, 2011, 86, (1), 66–70.

The optical diagnostic system of KSTAR consists of visible diagnostics including toroidal and poloidal Hα monitors, a visible survey spectrometer, and filterscopes. A re-entrant cassette made of stainless steel, containing five optical quartz windows has been developed to allow easy access of the visible diagnostics to the plasma. The configuration and manufacturing design of the diagnostic cassette and the installation of optical diagnostic systems within the cassette are described. The structural and thermal analysis of the diagnostic cassette and *in situ* calibration of optical diagnostics have also been performed. The optical lens system showed good image quality by spot diagram analysis.

11/02756 Efficiency enhancement in dye-sensitized solar cells by interfacial modification of conducting glass/mesoporous TiO_2 using a novel ZnO compact blocking film

Liu, Y. *et al. Journal of Power Sources*, 2011, 196, (1), 475–481.

A novel and thin ZnO compact blocking film is employed at the interface of fluorine-doped tin oxide (FTO) substrate and mesoporous TiO_2, and its influence on dye-sensitized solar cells (DSSCs) is investigated. The ZnO film prepared by spin-coating method on FTO is characterized by energy-dispersive X-ray spectroscopy (EDX), scanning electron microscopy (SEM), and UV–vis spectrophotometer. The ZnO film is firstly employed as an energy barrier between FTO and mesoporous TiO_2 film in DSSCs, which improves open-circuit photovoltage (V_{oc}) and fill factor (FF) with compensation of J_{sc} decrease, finally increasing energy conversion efficiency from 5.85% to 6.70%. Electrochemical impedance spectra (EIS) analysis and open-circuit voltage decay (OCVD) technique reveal that the existence of the energy barrier not only resulted in the effect of suppressing back electrons transfer from FTO to electrolyte but also blocking the electrons injection from the conductive band of TiO_2 to FTO. The former effect effectively reduces the recombination which occurs in the region of FTO substrate, and the latter leads to remarkable increment of electron density in the TiO_2, thus resulting in enhanced V_{oc} and FF. These results suggest that the methodology of introducing the semiconductor with a more negative conduction band edge than TiO_2 as the compact blocking film in DSSCs may be feasible.

11/02757 Simulation study of production of fine ceramic powders in a cyclone reactor

Manenti, G. and Masi, M. *Chemical Engineering and Processing: Process Intensification*, 2011, 50, (2), 151–159.

A numerical simulation study of production of fine ceramic powders in an innovative vapour-phase aerosol reactor is described. Arrangement is typical of reverse-flow cyclone equipment; no similar device is present in current scientific literature and industrial technology. The cyclone reactor has a potential technological application as it realizes process intensification by two simultaneous operating advantages: (i) curly flow reduces recirculation of as-synthesized particles towards flame region, and (ii) cyclone arrangement segregates large particles. As a result, ceramic powders with narrower particle size distribution can be produced with regard to traditional equipment. The study is based on the re-modelling of an existing industrial reactor for production of fine TiO_2 according to a cyclone configuration; particle size distributions from simulation and plant are compared.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

11/02758 A comprehensive approach for estimating thermo-physical properties of biodiesel fuels

Anand, K. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 235–242.
Among the various alternative fuels, biodiesel is emerging as a promising choice for compression ignition engines due to its renewable nature and superior emission characteristics. The experimental investigations conducted by various researchers on variety of biodiesel fuels show a wide variation in engine performance and emission characteristics. The lack of correlations predicting various physical properties of biodiesel fuels derived from different feed stocks is posing a serious limitation to the combustion modellers. The present study attempts to evolve a comprehensive methodology for estimating the properties of biodiesel fuels based on their composition and chemical structure.

11/02759 A multi-actor multi-criteria framework to assess the stakeholder support for different biofuel options: the case of Belgium

Turcksin, L. *et al. Energy Policy*, 2011, 39, (1), 200–214.
The multi-actor multi-criteria analysis (MAMCA) is a methodology to evaluate different policy measures, whereby different stakeholders' opinions are explicitly taken into account. In this paper, the framework is used to assess several biofuel options for Belgium that can contribute to the binding target of 10% renewable fuels in transport by 2020, issued by the renewable energy directive (RED). Four biofuel options [biodiesel, ethanol, biogas and synthetic biodiesel (also referred to as 'biomass-to-liquid' or BTL)] together with a reference fossil fuel option, are evaluated on the aims and objectives of the different stakeholders involved in the biofuel supply chain (feedstock producers, biofuel producers, fuel distributors, end users, vehicle manufacturers, government, non-governmental organizations and north–south organizations). Overall, the MAMCA provided insights in the stakeholder's position and possible implementation problems for every biofuel option. As such, it helps decision makers in establishing a supportive policy framework to facilitate implementation and to ensure market success, once they have decided on which biofuel option (or combination of options) to implement.

11/02760 A short-term scheduling for the optimal operation of biorefineries

Grisi, E. F. *et al. Energy Conversion and Management*, 2011, 52, (1), 447–456.
This work presents an analysis of the inherent potentialities and characteristics of the sugarcane industries that produce sugar, bioethanol, biogas and bioelectricity and that are being described as 'biorefineries'. These biorefineries are capable of producing bio-energy under diverse forms, intended for their own internal consumption and for external sales and marketing. A complex model and simulation are carried out of the processes of a sugarcane industry, with the data characteristic as well as the production costs, prices of products and considerations on the energy demand by basic processes. A mixed-integer linear programming (MILP) optimization problem formulation and an analysis of optimal solutions in short-term operation are described, taking into account the production cost functions of each commodity and the incomes obtained from selling electricity and other products. The objective is to maximize the hourly plant economic profit in the different scenarios considered in a real case study.

11/02761 A simple model for super critical fluid extraction of bio oils from biomass

Patel, R. N. *et al. Energy Conversion and Management*, 2011, 52, (1), 652–657.
A simple mathematical model to characterize the supercritical extraction process has been proposed in this paper. This model is primarily based on two mass transfer mechanisms: solubility and diffusion. The model assumes two districts mode of extraction: initial constant rate extraction that is controlled by solubility and falling rate extraction that is controlled by diffusivity. Effects of extraction parameters such as pressure and temperature on the extraction of oil have also been studied. The proposed model, when compared with existing models, shows better agreement with the experimental results. The proposed model developed has been applied for both high initial oil content material (cashew nut shells) and low initial oil content material (black pepper).

11/02762 Antimicrobial strategies for limiting bacterial contaminants in fuel bioethanol fermentations

Muthaiyan, A. *et al. Progress in Energy and Combustion Science*, 2011, 37, (3), 351–370.
Bioethanol continues to be offered as a viable solution for complex problems ranging from global warming and national energy security to local economic development. Fuel bioethanol burns cleaner than gasoline, is derived from renewable agricultural products, and creates local jobs and income. In December 2007, President Bush signed into law the Energy Independence and Security Act, which increased the renewable fuel standard that was mandated under energy Policy Act of 2005 to 36 billion gallons by 2022.In order to achieve this goal, ethanol production would need to be generated primarily from corn and cellulosic materials. Bioethanol producers are currently involved in variety of technological innovations to reduce energy consumption and production costs, increased efficiency and reduced emissions using the best available control technologies. However, industrial ethanol fermentation is a non-sterile process and contaminant microorganisms can lead to a decrease in industrial productivity and significant economic loss. Currently, bioethanol industries use different antimicrobials including antibiotics to control the contaminants in the fermentors. The emergence of antibiotic resistance among contaminant bacteria in bioethanol fermentors warrants the need for alternative antimicrobials to retain bioethanol production at a profitable level. In addition more and more ethanol producers are seeking to generate distillers grains that can be labelled antibiotic free to be sold in international markets where some restrictions are already in place for reducing and/or eliminating antibiotics usage in animal feed. This review examines the contamination problems, various intervention methods, emergence of antibiotic resistance in contaminant bacteria, and potential alternative options to elucidate antimicrobial products from various natural sources. In particular, emphasis has been given for natural antibacterial products from plant derived products to suggest a new research avenue for the search of new, non-conventional antimicrobial agents to control the contamination problem in the fuel bioethanol industries.

11/02763 Application of proton exchange membrane fuel cells for the monitoring and direct usage of biohydrogen produced by *Chlamydomonas reinhardtii*

Oncel, S. and Vardar-Sukan, F. *Journal of Power Sources*, 2011, 196, (1), 46–53.
Photo-biologically produced hydrogen by *Chlamydomonas reinhardtii* is integrated with a proton exchange (PEM) fuel cell for online electricity generation. To investigate the fuel cell efficiency, the effect of hydrogen production on the open circuit fuel cell voltage is monitored during 27 days of batch culture. Values of volumetric hydrogen production, monitored by the help of the calibrated water columns, are related with the open circuit voltage changes of the fuel cell. From the analysis of this relation a dead end configuration is selected to use the fuel cell in its best potential. After the open circuit experiments external loads are tested for their effects on the fuel cell voltage and current generation. According to the results two external loads are selected for the direct usage of the fuel cell incorporating with the photobioreactors (PBR). Experiments with the PEM fuel cell generate a current density of $1.81\,\mathrm{mA\,cm^{-2}}$ for about 50 h with $10\,\Omega$ load and $0.23\,\mathrm{mA\,cm^{-2}}$ for about 80 h with $100\,\Omega$ load.

11/02764 Biodiesel production from pomace oil by using lipase immobilized onto olive pomace

Yücel, Y. *Bioresource Technology*, 2011, 102, (4), 3977–3980.
In the present work, microbial lipase from *Thermomyces lanuginosus* was immobilized by covalent binding onto olive pomace. Immobilized support material used to produce biodiesel with pomace oil and methanol. The properties of the support and immobilized derivative were evaluated by scanning electron microscopy (SEM). The maximum immobilization of *T. lanuginosus* was obtained as 18.67 mg/g support and the highest specific activity was 10.31 U/mg protein. The properties of immobilized lipase were studied. The effects of protein concentration, pH and buffer concentration on the immobilization and lipase activity were investigated. Biodiesel production using the immobilized lipase was realized by a three-step addition of methanol to avoid strong substrate inhibition. Under the optimized conditions, the maximum biodiesel yield was 93% at 25 °C in 24 h reaction. The immobilized enzyme retained its activity during the 10 repeated batch reactions.

11/02765 Biomass energy production in agriculture: a weighted goal programming analysis

Ballarin, A. *et al. Energy Policy*, 2011, 39, (3), 1123–1131.

Energy production from biomasses can be an important resource that, when combined with other green energies such as wind power and solar plants, can contribute to reduce dependency on fossil fuels. The aim of this study is to assess how agriculture could contribute to the production of bio-energy. A multi-period weighted goal programming model (MpWGP) has been applied to identify the optimal land use combinations that simultaneously maximize farmers' income and biomass energy production under three concurrent constraints: water, labour and soil availability. Alternative scenarios are considered that take into account the effect of climate change and social change. The MpWGP model was tested with data from the Rovigo county area (Italy) over a 15-year time period.

11/02766 Biotechnological conversions of biodiesel derived waste glycerol by yeast and fungal species

Chatzifragkou, A. *et al. Energy*, 2011, 36, (2), 1097–1108.

Fifteen eukaryotic microorganisms were tested for their ability to assimilate biodiesel-derived waste glycerol and convert it into value-added metabolic products. For this purpose yeast and Zygomycetes strains were cultivated in nitrogen-limited raw glycerol-based media (initial glycerol concentration 30 g/L). Yeasts tested accumulated restricted lipid quantities (up to $\sim$22%, wt/wt, in the case of *Rhodotorula* sp.), while differentiations in their fatty acid composition were recorded in relation to the yeast strains employed and the fermentation time. On the contrary, fungi accumulated higher quantities of lipid inside their mycelia (ranging between 18.1 and 42.6%, wt/wt, of dry biomass) that contained in variable amounts the medically important GLA (γ-linolenic acid). Moreover, *Yarrowia lipolytica*, *Pichia membranifaciens* and *Thamnidium elegans* were further studied in media having increased initial glycerol concentrations. In these conditions *Y. lipolytica* secreted significant amounts of acetic acid (29.2 g/L), as well as mannitol (19.4 g/L) while *P. membranifaciens* reached 28.4 g/L of biomass at glycerol concentration 90 g/L. *T. elegans* produced 11.6 g/L of oil, with 71.1%, wt/wt, of fat in biomass, while the maximum concentration of GLA was 371 mg/L. Detailed analysis of *T. elegans* lipids indicated that the phospholipids fraction was particularly rich in polyunsaturated fatty acids.

11/02767 Brønsted imidazolium ionic liquids: synthesis and comparison of their catalytic activities as pre-catalyst for biodiesel production through two stage process

Elsheikh, Y. A. *et al. Energy Conversion and Management*, 2011, 52, (2), 804–809.

In the present work, study was undertaken to prepare biodiesel via a two-step transesterification process. The high free fatty acids (FFA) value contained in the crude palm oil (CPO), which cause several problems with the straight alkaline-catalysed, were converted to fatty acid methyl esters (FAME) before introducing KOH-catalysed transesterification step. In order to evaluate their catalytic activities, three Brønsted acidic imidazoliums were investigated. These ionic liquids (ILs) appeared to be promising candidates to replace conventional acidic catalyst for biodiesel production due to their unique properties. Among them, a longer side chains 1-butyl-3-methyl-imidazolium hydrogensulfate (BMIMHSO$_4$) was found to be more superior to the other two catalysts. Based on the experimental results, a catalyst (BIMHSO$_4$) concentration of 4.5 wt%, methanol/CPO molar ratio of 12:1, a temperature of 160 °C, and agitation speed of 600 rpm provided a final CPO acid value lower than 1.0 mg KOH/CPO within 120 min. The second alkali-catalyse step was performed at agitation speed of 600 rpm, 60 °C, 1.0% KOH for 50 min. The final biodiesel product in 98.4% yield was analysed by gas chromatography. The determined physicochemical important properties of POME were confirmed with American Standards for Testing and Materials.

11/02768 Characterisation of bio-oil from fast pyrolysis of rice husk in a fluidised bed reactor

Liu, R. H. *et al. Journal of the Energy Institute*, 2011, 84, (2), 73–79.

Bio-oil was produced by the fast pyrolysis of rice husk and the physicochemical properties of the bio-oil were analysed. The results showed that bio-oil has a relatively high water content (47.05%), high ash content (0.29%), high carbon residue (5.84%) and low higher heating value (16.42 MJ kg^{-1}). The density, kinetic viscosity at room temperature and pH value of the bio-oil were 1100 kg m^{-3}, 3.41 mm^2 s^{-1} and 3.23 respectively. Simultaneously, the kinetic viscosity of the bio-oil decreased significantly with increasing measurement temperature from 25 to 100 °C, and its prominent viscosity–temperature characteristics were proved. Analysis of chemical functional groups and chemical structure of the bio-oil through Fourier transformation infrared spectrometer and Fourier transformation nuclear magnetic resonance technologies demonstrated the complexity of chemical compositions of the rice husk bio-oil.

11/02769 Comparative analysis for power generation and ethanol production from sugarcane residual biomass in Brazil

Seabra, J. E. A. and Macedo, I. C. *Energy Policy*, 2011, 39, (1), 421–428.

This work compares the technical, economic and environmental (greenhouse gas emissions mitigation) performance of power generation and ethanol production from sugarcane residual biomass, considering conversion plants adjacent to a sugarcane mill in Brazil. Systems performances were simulated for a projected enzymatic saccharification co-fermentation plant (ethanol option) and for a commercial steam-Rankine power plant (electricity option). Surplus bagasse from the mill would be used as fuel/raw material for conversion, while cane trash collected from the field would be used as supplementary fuel at the mill. For the electricity option, the sugarcane biorefinery (mill and adjacent plant) would produce 91 L of ethanol per tonne of cane and export 130 kWh/t of cane, while for the ethanol option the total ethanol production would be 124 L/t of cane with an electricity surplus of 50 kWh/t cane. The return on investment (ROI) related to the biochemical conversion route was 15.9%, compared with 23.2% for the power plant, for the conditions in Brazil. Considering the greenhouse gas emissions mitigation, the environmentally preferred option is the biochemical conversion route: the net avoided emissions associated to the adjacent plants are estimated to be 493 and 781 kgCO$_2$eq/t of dry bagasse for the electricity and ethanol options, respectively.

11/02770 Compatibility of automotive materials in biodiesel: a review

Haseeb, A. S. M. A. *et al. Fuel*, 2011, 90, (3), 922–931.

Use of biodiesel in automobiles can significantly reduce dependence on fossil fuels and help reduce environmental pollution. However, there are concerns over the compatibility of currently used automotive materials in biodiesel. A few automobile manufacturers extended their warranty only to lower blends of biodiesel (e.g. B5). Higher blends (e.g. B50 or B100) are still not covered by warranty. In automobile fuel system, metallic materials like ferrous alloy and non-ferrous alloys, and elastomers come in contact with fuel. Biodiesel, having different chemical characteristics from diesel, can interact with materials in a different way. It can cause corrosive and tribological attack on metallic components and degrade elastomer parts. This paper attempts to present an overview of the work done so far on the compatibility of biodiesel with automotive materials.

11/02771 Effects of multiple-injection strategies on overall spray behavior, combustion, and emissions reduction characteristics of biodiesel fuel

Park, S. H. *et al. Applied Energy*, 2011, 88, (1), 88–98.

This study describes the combustion and exhaust emissions characteristics of biodiesel fuel with multiple-injection strategies. Also, this investigation includes the free spray characteristics and in-cylinder spray behaviours of the multiple-injection modes. Free spray and in-cylinder spray images were obtained from the spray visualization system. Combustion and exhaust emissions characteristics were analysed using a single cylinder diesel engine with a displacement volume of 373.33 cm^3 and a compression ratio of 17.8. The exhaust emissions were analysed using a smoke meter and an exhaust gas analyser. A scanning mobility particle sizer (SMPS) was used to measure the particle number and size distribution of the nano-sized particle matter. It revealed that the injected spray before BTDC 25° developed toward the piston bowl region, and then progressed along the piston wall. When the biodiesel spray was injected at BTDC 25°, the spray targeted the piston lib. In single-injection combustion, the combustion pressure and rate of heat release at an injection timing of BTDC 30° dramatically decreased. These characteristics influenced on the decrease of the indicated mean effective pressure (IMEP) and the increase of soot, HC, and CO emissions because of the incomplete combustion. The multiple-injection modes showed a higher IMEP than the single-injection mode. In addition, the pilot injection strategy represented a higher IMEP than the split injection mode. The analysis of exhaust emissions characteristics of the multiple-injection modes showed that a short injection interval induced a decrease in soot, HC, and CO emissions, while NO$_x$ emission increased. On the other hand, when the multiple-injection modes applied to the diesel engine, particles with large sizes were significantly decreased compared to single-injection combustion.

11/02772 Energy utilisation of biowaste – sunflower-seed hulls for co-firing with coal

Raclavska, H. *et al. Fuel Processing Technology*, 2011, 92, (1), 13–20.

Sunflower-seed hulls (SSH) represent a source of combustible biomass characterised by high contents of potassium and phosphorus and a low silica content. The relatively high net calorific value of 20 MJ/kg d.m. is mainly influenced by the lignin content. Potassium and phosphorus are very important elements in biomass combustion for fuel, influencing slagging and fouling problems. Mixtures with different ratios of brown coal and sunflower-seed hulls (0–22% SSH) were co-fired in the Olomouc power plant. The behaviour of elements in the fly ash and the bottom ash (SiO_2, Al_2O_3, K_2O, P_2O_5, Zn, Cu and Cd) varied in relation to the amount of SSH added to the coal. The fly ash from the co-firing of 20% SSH with coal had a high content of water-leachable sulfates and total dissolved solids. The utilization of fly ash in civil engineering (land reclamation) should fulfil criteria established by the Council Decision 2003/33/EC for non-hazardous waste. To ensure that the required water-leachable sulfate concentrations are within regulatory limits the fuel may contain a maximum of 14% SSH.

11/02773 Enhanced bio-oil production from swine manure co-liquefaction with crude glycerol

Xiu, S. *et al. Energy Conversion and Management*, 2011, 52, (2), 1004–1009.

Swine manure was treated by a high-pressure reactor for bio-oil production over a temperature range 260–360 °C and a retention time of 5–90 min. The effect of temperature, retention time and crude glycerol addition on the oil yield and quality of liquefaction process of swine manure was investigated. Temperature showed important effects both on oil yield and oil quality. Increasing temperature from 260 to 340 °C was found to increase the oil yield, carbon content, and heating value of the oil. Retention time affected the completeness of the liquefaction process. Extending the retention time was found to have more influence on the quantity rather than the quality of oil product. The highest oil yield was obtained at 24% on a dry matter basis at reaction temperature of 340 °C and retention time of 15 min. At the optimum conditions, crude glycerol was added in the swine manure slurry at different ratios in order to evaluate the use of glycerol as a co-substrate, to improve the bio-oil production during the liquefaction process. The oil yield increased dramatically by adding crude glycerol as the co-substrate at different manure to crude glycerol ratio. Specifically, by adding three parts of crude glycerol into one part of swine manure, the oil yield increased to 68% (g/g dry matter). However, increasing the crude glycerol addition negatively affected both the carbon content and heating value of oil.

11/02774 Enzyme deactivation during biodiesel production

Maceiras, R. *et al. Chemical Engineering Journal*, 2011, 166, (1), 358–361.

Enzymatic conversion of vegetable oils into biodiesel offers an environmentally more attractive option to the conventional processes. However, lipase can be deactivated by lower linear alcohols, such as methanol and ethanol, conventionally used in biodiesel process. In this work, transesterification reactions of waste frying oil were carried out in presence of two different acyl acceptors in order to analyse its influence on the free and immobilized lipase activity.

11/02775 Evidence of thermal decomposition of fatty acid methyl esters during the synthesis of biodiesel with supercritical methanol

Quesada-Medina, J. and Olivares-Carrillo, P. *The Journal of Supercritical Fluids*, 2011, 56, (1), 56–63.

New evidence on the thermal decomposition of fatty acid methyl esters during biodiesel synthesis in supercritical conditions is presented. Thermal decomposition products were detected chromatographically, by applying the UNE-EN 14105:2003 standard, as a broad single peak during the determination of glycerides in the reaction samples. These degradation products could be quantified chromatographically by the above standard because the area of the peak was proportional to the disappearance of the polyunsaturated fatty acid methyl esters, which contain two or more double bonds (methyl linoleate and linolenate), generated during biodiesel synthesis from soybean oil. In the experimental conditions tested, thermal decomposition reactions of these unsaturated fatty acid methyl esters began to appear at 300 °C/26 MPa, and were more intense as the temperature rose. For its part, the main saturated fatty acid methyl ester (methyl palmitate) generated during the reaction was hardly decomposed at all in the experimental conditions tested and only began to disappear at 350 °C/43 MPa.

11/02776 Experimental and kinetic study of the NO-reduction by tar formed from biomass gasification, using benzene as a tar model component

Zhang, R.-Z. *et al. Fuel Processing Technology*, 2011, 92, (1), 132–138.

The present work studies the combustion of biomass syngas to characterize the NO-reduction by tar, benzene being selected as the representative model tar component. Experiments were carried out in a tubular flow reactor at atmospheric pressure and at different operating conditions, i.e. an equivalence ratio of 0.5 to 2.5, temperatures between 1173 and 1673 K and a reaction residence time of 50 to 100 ms. Kinetic parameters were determined from the experimental results. A simplified scheme of NO-reduction by benzene was presented and the effects of operating variables were concluded. The NO conversion is favoured by an oxygen-rich condition, and the reduction efficiency falls with the rise of equivalence ratio, especially in the range of 0.5–1.0. Although high temperature enhances the reduction reactions, soot formation at high temperatures (1573 K, 1673 K) will seriously hinder the reduction of NO, which should be prevented. The ideal temperature is about 1473 K. It was found that 50 ms was an insufficient residence time for the reduction. An increased contact time is of higher benefit at 1673 K where the heterogeneous reactions between NO and graphitized heavy hydrocarbons have a lower reaction rate. High pre-exponential factors and low activation energies are achieved under oxygen-rich conditions.

11/02777 Impact of biodiesel bulk modulus on injection pressure and injection timing. The effect of residual pressure

Caresana, F. *Fuel*, 2011, 90, (2), 477–485.

As the demand for energy rises fossil fuel reserves are depleted daily, increasing the interest in alternative fuels. Biodiesel is one of the best candidates in this class and its use is expected to expand rapidly throughout the world. Numerous researchers have been investigating how biodiesel affects combustion, pollutant formation and exhaust aftertreatment. There is general agreement that its combustion characteristics are similar to those of standard diesel fuel, except for a shorter ignition delay, a higher ignition temperature, and greater ignition pressure and peak heat release. Engine power output is similar with both fuels. As regards emissions, reductions in particulate matter (PM) and carbon monoxide (CO) and increases in nitrogen oxides (NO_x) are described with most biodiesel blends. The latter is referred to as the 'biodiesel NO_x effect'. The vast majority of researchers who explored the effect of biodiesel did so in mechanical injection engines. They found that the primary mechanism by which biodiesel increases NO_x emissions is by an inadvertent advance in the start of injection timing, caused by a higher modulus and viscosity. However, more recent studies show that NO_x emissions also increase in biodiesel-fuelled common rail engines, and that in some cases they actually decrease in engines with mechanically controlled fuel injection systems. This cannot be explained solely by differences in compressibility and remains an open question. The present study provides a contribution to the discussion in this field by describing a new method to evaluate the injection advance in engines with mechanically controlled pumps. The experimental data show that the advances in the start of injection timing, using biodiesel rather than mineral diesel, are smaller than those calculated with standard methods and may even not occur at all, depending on injection system design. In addition, they demonstrate that, contrary to common belief, injection pressure does not always increase when using biodiesel. These data may help explain why some researchers have found similar or even reduced NO_x emission also with mechanical injection systems.

11/02778 Importance of algae oil as a source of biodiesel

Demirbas, A. and Demirbas, M. F. *Energy Conversion and Management*, 2011, 52, (1), 163–170.

Algae are the fastest-growing plants in the world. Industrial reactors for algal culture are open ponds, photobioreactors and closed systems. Algae are very important as a biomass source. Algae will some day be competitive as a source for biofuel. Different species of algae may be better suited for different types of fuel. Algae can be grown almost anywhere, even on sewage or salt water, and does not require fertile land or food crops, and processing requires less energy than the algae provides. Algae can be a replacement for oil-based fuels, one that is more effective and has no disadvantages. Algae are among the fastest-growing plants in the world, and about 50% of their weight is oil. This lipid oil can be used to make biodiesel for cars, trucks, and airplanes. Microalgae have much faster growth-rates than terrestrial crops. The per unit area yield of oil from algae is estimated to be from 20,000 to 80,000 l per acre, per year; this is 7–31 times greater than the next best crop, palm oil. The lipid and fatty acid contents of microalgae vary in accordance with culture conditions. Most current research on oil extraction is focused on microalgae to produce biodiesel from algal oil. Algal-oil processes into biodiesel as easily as oil derived from land-based crops.

11/02779 Internal particle size distribution of biofuel pellets

Jensen, P. D. *et al. Fuel*, 2011, 90, (3), 980–986.

Several methods for disintegration of biofuel pellets were tested and compared for their ability to break up the pellets into the original particles of the raw material. Analyses performed on softwood pellets and straw pellets concluded that wet disintegration in water at ambient temperature is insufficient for a determination of the internal particle size distribution of wood- and straw pellets. When the wet disintegration was performed with water heated to the boiling point and coupled with mechanical disintegration in terms of stirring a more complete disintegration of the pellets was obtained. Based on the results obtained in the initial study a round robin was set up including six European laboratories where the selected method was tested. In the round-robin test the method combining heated water and stirring of the slurry was tested on solid biofuel pellets produced of comminute straw, deciduous wood and coniferous wood respectively. With the method a satisfactory disintegration was obtained of all three types of pellets. Further wet disintegration of coniferous pellets was compared to a dry disintegration using a hammer mill. The dry disintegration of the coniferous pellets resulted in smaller particle sizes compared to the wet disintegration using heated water and stirring of the slurry indicating a further disintegration of the original particles in the hammer mill process. Overall the wet disintegration combined with mechanical impact was found to be the most suitable method for disintegration of solid biofuel pellets. Combined with sieving analysis the method gives realistic image of the internal particle size distribution of solid biofuel pellets.

11/02780 Optimization of thermal-dilute sulfuric acid pretreatment for enhancement of methane production from cassava residues

Zhang, Q. *et al. Bioresource Technology*, 2011, 102, (4), 3958–3965.

In this study, the pretreatment of cassava residues by thermal-dilute sulfuric acid (TDSA) hydrolysis was investigated by means of a statistically designed set of experiments. A three-factor central composite design (CCD) was employed to identify the optimum pretreatment condition of cassava residues for methane production. The individual and interactive effects of temperature, H_2SO_4 concentration and reaction time on increase of methane yield (IMY) were evaluated by applying response surface methodology (RSM). After optimization, the resulting optimum pretreatment condition was 157.84 °C, utilizing 2.99% (w/w TS) H_2SO_4 for 20.15 min, where the maximum methane yield (248 mL/g VS) was 56.96% higher than the control (158 mL/g VS), which was very close to the predict value 56.53%. These results indicate the model obtained through RSM analysis is suit to predict the optimum pretreatment condition and there is great potential of using TDSA pretreatment of cassava residues to enhance methane yield.

11/02781 Preparation of bio-fuels by catalytic cracking reaction of vegetable oil sludge

Nam, L. T. H. *et al. Fuel*, 2011, 90, (3), 1069–1075.

Biofuel production from vegetable oil is potentially a good alternative to conventional fossil derived fuels. Moreover, liquid biofuel offers many environmental benefits since it is free from nitrogen and sulfur compounds. Biofuel can be obtained from biomass (e.g. pyrolysis, gasification) and agricultural sources such as vegetable oil, vegetable oil sludge, rubber seed oil, and soybean oil. One of the most promising sources of biofuel is vegetable oil sludge. This waste is a major byproduct of vegetable oil factories. It consists of triglycerides (61%), free fatty acid (37%) and impurities (2%). The hydrocarbon chains of triglycerides and free fatty acid are mainly made up of C_{16} (30%) and C_{18} (36%) hydrocarbons. The others consist of C_{12}–C_{17} hydrocarbon chains. Transesterification can help in converting vegetable oil sludge into biofuel. The disadvantage of this method is that a large amount of methanol is required. The alternative method for this conversion is catalytic cracking. The objective of this research is to evaluate and compare the pyrolysis process with cracking catalytic reaction of vegetable oil sludge by Micro-activity test MAT 5000 of Zeton-Canada. A ZSM-5/MCM-41 multiporous composite (MC-ZSM-5/MCM-41), was successfully synthesized using silica source extracted from rice husk. The material has the MCM-41 mesoporous structure, and its wall is constructed by ZSM-5 nanozeolite crystals. The porous system of the material includes pores of the following sizes: 5 Å (ZSM-5 zeolite), 40 Å (MCM-41 mesoporous material), and another porous system whose diameter is in the range of 100–500 Å (mesoporous system) formed by the burning of organic compounds that remain in the material during the calcination process. This pore system contributes to an increase in the catalytic performance of synthesized material. The results of vegetable oil sludge cracking reaction show that the product consists of fractions such as dry gas, liquefied petroleum gas (LPG), gasoline, light cycle oil (LCO), and (heavy cycle oil) HCO, which are similar to those of petroleum cracking process. MC-ZSM-5/MCM-41 catalyst is efficient in the catalytic cracking reaction of vegetable oil sludge as it has higher conversion and selectivity for LPG and gasoline products in comparison to the pyrolysis process. Product distribution (percentage of oil feed) of cracking reaction over MC-ZSM-5/MCM-41 is coke (3.4), total dry gas (7.0), LPG (31.1), gasoline (42.4), LCO (8.9), HCO (7.2); and that of pyrolysis are coke (19.0), total dry gas (9.3), LPG (16.9), gasoline (28.8), LCO (13.7), and HCO (12.3). These results have indicated a new way to use agricultural waste such as rice husk for the production of promising catalysts and the processing of vegetable oil sludge to obtain biofuel.

11/02782 Production of biodiesel from *Jatropha* oil catalyzed by nanosized solid basic catalyst

Deng, X. *et al. Energy*, 2011, 36, (2), 777–784.

In this work, hydrotalcite-derived particles with Mg/Al molar ratio of 3/1 were synthesized by a coprecipitation method using urea as precipitating agent, subsequently with (MHT) microwave-hydrothermal treatment, and followed by calcination at 773 K for 6 h. These particles were micro-sized mixed Mg/Al oxides as characterized by SEM and AFM. But actually they were nanosized according to the calculations from XRD data. Because of their strong basicity, the nanoparticles were further used as catalyst for biodiesel production from *Jatropha* oil after pretreatment. Experiments were conducted with the solid basic catalyst in an ultrasonic reactor under different conditions. At the optimized condition, biodiesel yield of 95.2% was achieved, and the biodiesel properties were close to those of the German standard. The catalyst can be reused for eight times.

11/02783 Production of microbial oil with high oleic acid content by *Trichosporon capitatum*

Wu, H. *et al. Applied Energy*, 2011, 88, (1), 138–142.

Microbial oils with high unsaturated fatty acids content, especially oleic acid content, are good feedstock for high-quality biodiesel production. *Trichosporon capitatum* was found to accumulate lipid with around 80% oleic acid and 89% total unsaturated fatty acids content on nitrogen-limited medium. In order to improve its lipid yield, effects of medium components and culture conditions on cell growth and lipid accumulation were investigated. Optimization of media resulted in a 61% increase in the lipid yield of *T. capitatum* after cultivation at 28 °C and 160 rpm for 6 days. In addition, *T. capitatum* could grow well on cane molasses and afford a lipid yield comparable to that on synthetic nitrogen-limited medium. The biodiesel from the microbial oil produced by *T. capitatum* on cane molasses displayed a low cold filter plugging point (−15 °C), and so *T. capitatum* might be a promising strain to provide lipid suitable for high quality biodiesel production.

11/02784 Separation and recovery of the constituents from lignocellulosic biomass by using ionic liquids and acetic acid as co-solvents for mild hydrolysis

van Spronsen, J. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (2), 196–199.

Previously, ionic liquids were found to partially dissolve lignocellulosic biomass. Here, it is reported that the biomass itself does not dissolve directly, but that it is hydrolysed first before the constituents (cellulose, hemicellulose and lignin) dissolve into the ionic liquid. By addition of an acidic catalyst, this hydrolysis step can take place at milder conditions. Acetic acid is chosen as a suitable acidic catalyst, because it is already present in lignocellulosic biomass in the form of acetyl groups on the hemicellulose. Here, it is shown that acetic acid also works as co-solvent, increasing the solubility of the constituents of lignocellulosic biomass in the ionic liquid. The milder conditions for hydrolysis result in a higher degree of utilization of the lignocellulosic biomass, whereby all constituents can be fully recovered and further processed and the ionic liquid can be reused.

11/02785 Simulation of the heating performance of the Kang system in one Chinese detached house using biomass

Cao, G. *et al. Energy and Buildings*, 2011, 43, (1), 189–199.

A traditional Chinese heating system, the Chinese Kang, is used by 175 million people in detached houses in the rural regions of China, especially in north-east China. This system utilizes biomass such as corn stalks, straw, corncob and energy plants as the heat sources. The objective of this paper is to establish a set of models to simulate the energy performance of the Kang heating system in one Chinese detached house. An experimental field study was carried out to collect practical parameters in a newly constructed Chinese detached house. The dynamic performance of the Kang heating system was simulated by using IDA-ICE 4.0 embedded with an empirical model built in the field study. The results show that the simulation can obtain good overall agreement with the field measurement results. It was confirmed that the Kang model created by IDA-ICE 4.0 is capable of simulating the performance of the Kang system and of calculating energy consumption in the detached house. Moreover, the result reveals that the thermal environment in the present Chinese detached house is still poor during the severe cold season if only the Kang system is used to heat the whole house.

11/02786 Stakeholder perceptions of biofuels from microalgae

Oltra, C. *Energy Policy*, 2011, 39, (3), 1774–1781.

This paper focuses on stakeholder views around the development of advanced biofuels from microalgae. Research for the development of microalgal-derived biofuels was initiated by the US Department of Energy (DOE) more than 30 years ago. However, interest in this eco-innovation has been growing significantly over the past 5 years in various countries. The high productivity of algae indicates that algal biofuels could contribute to reduce our dependence on fossil fuels while avoiding the undesired impacts of first generation biofuels. There are still numerous challenges that need nevertheless to be addressed.

The aim of this paper is to explore stakeholder perceptions of the current barriers and opportunities associated with this promising emergent technology.

11/02787 Statistical optimization for biodiesel production from waste frying oil through two-step catalyzed process

Charoenchaitrakool, M. and Thienmethangkoon, J. *Fuel Processing Technology*, 2011, 92, (1), 112–118.

The aim of this work was to investigate the optimum conditions in biodiesel production from waste frying oil using two-step catalysed process. In the first step, sulfuric acid was used as a catalyst for the esterification reaction of free fatty acid and methanol in order to reduce the free fatty acid content to be approximate 0.5%. In the second step, the product from the first step was further reacted with methanol using potassium hydroxide as a catalyst. The Box–Behnken design of experiment was carried out using the MINITAB 14, and the results were analysed using response surface methodology. The optimum conditions for biodiesel production were obtained when using methanol to oil molar ratio of 6.1:1, 0.68 wt% of sulfuric acid, at 51 °C with a reaction time of 60 min in the first step, followed by using molar ratio of methanol to product from the first step of 9.1:1, 1 wt% KOH, at 55 °C with a reaction time of 60 min in the second step. The percentage of methyl ester in the obtained product was 90.56 ± 0.28%. In addition, the fuel properties of the produced biodiesel were in the acceptable ranges according to Thai standard for community biodiesel.

11/02788 The Brazilian sugarcane innovation system

Furtado, A. T. *et al. Energy Policy*, 2011, 39, (1), 156–166.

Ethanol has recently been of great interest worldwide because it is a viable economic alternative to petroleum products and it is a renewable source of energy that mitigates the emission of greenhouse gases. Brazilian bioethanol from sugarcane is the most successful case at the world level because of its low cost and low level of greenhouse gas emissions. Brazil's success with sugarcane cannot be understood as based solely on a natural comparative advantage, but as a result of efforts that culminated in a positive trajectory of technological learning, relying mostly on incremental innovations. The purpose of this article is to analyse the key aspects of the innovation system built around the Brazilian sugarcane industry. It is based on the national innovation systems approach according to which innovation results from the interaction of different institutional actors. Institutional arrangements are analysed as the basis for the innovative process, in particular research and development and the innovation policies and strategies of the main players in the sugarcane sector, including sugar and ethanol mills, industrial goods suppliers, public and private research institutions, and governmental agencies.

11/02789 Torrefaction and co-torrefaction characterization of hemicellulose, cellulose and lignin as well as torrefaction of some basic constituents in biomass

Chen, W.-H. and Kuo, P.-C. *Energy*, 2011, 36, (2), 803–811.

Torrefaction is a thermal pretreatment process for biomass where raw biomass is heated in the temperatures of 200–300 °C under an inert or nitrogen atmosphere. The main constituents contained in biomass include hemicellulose, cellulose and lignin; therefore, the thermal decomposition characteristics of these constituents play a crucial role in determining the performance of torrefaction of lignocellulosic materials. To gain a fundamental insight into biomass torrefaction, five basic constituents, including hemicellulose, cellulose, lignin, xylan and dextran, were individually torrefied in a thermogravimetry. Two pure materials, xylose and glucose, were torrefied as well for comparison. Three torrefaction temperatures of 230, 260 and 290 °C, corresponding to light, mild and severe torrefactions, were taken into account. The experiments suggested the weight losses of the tested samples could be classified into three groups; they consisted of a weakly active reaction, a moderately active reaction and a strongly active reaction, depending on the natures of the tested materials. Co-torrefactions of the blend of hemicellulose, cellulose and lignin at the three torrefaction temperatures were also examined. The weight losses of the blend were very close to those from the linear superposition of the individual samples, suggesting that no synergistic effect from the co-torrefactions was exhibited.

11/02790 Value-at-risk estimation with the optimal dynamic biofuel portfolio

Chang, T.-H. *et al. Energy Economics*, 2011, 33, (2), 264–272.

In the past, petroleum companies only paid attention to hedging the variation in the crude oil price and volatility. However, they have now expanded their analysis to encompass renewable sources, such as corn and soybeans, under the current low-carbon biofuel obligations. This paper employs GARCH(1,1) and ARJI models to estimate the one-day-ahead value-at-risk (VaR) of the optimal dynamic biofuel portfolio, which consists of crude oil, corn and soybeans. The optimal blended standard is subject to the dual limitations of minimum production costs and the lowest biofuel using requirements. The empirical findings confirm that the ARJI model is more suitable than the GARCH(1,1) model and further captures the discontinuous jump behaviour from the in-the-sample data. The results of out-of-sample forecasts also are represented that the models play important roles in VaR estimation and risk management for biofuel portfolio. The authors therefore suggest that the petroleum companies should simultaneously pay attention to jump risk in hedging material costs in the prices of energy-related crops.

11/02791 Variation on biomass yield and morphological traits of energy grasses from the genus *Miscanthus* during the first years of crop establishment

Jezowski, S. *et al. Biomass and Bioenergy*, 2011, 35, (2), 814–821.

This study presents the results of investigations of variation, genotype × year interactions and genotype × year × location interactions for the yield and morphological traits of several selected clones of energy grasses of the genus *Miscanthus*. The analyses were performed on the best clones of selected hybrid plants, which were obtained within the species *M. sinensis* or are the result of interspecific hybridization of *M. sinensis* and *M. sacchariflorus*. Analyses were conducted on the basis of 3-year field trials at two locations. The young plants produced from *in vitro* cultures were planted at a density of one plant per m^2. The early stages of plant development, from planting until peak yield in the third year of cultivation, were analysed. Statistical analyses performed on the yield and morphological traits as well as changes in these characteristics over the successive years of the study showed considerable genotypic variation for traits under study. Moreover, significant genotype × year interactions as well as genotype × year × location interactions were observed in terms of yield and morphological traits. Based on the collective results of the study, it is suggested that apart from *M.* × *giganteus* particularly hybrids of *M. sinensis* × *M. sacchariflorus*, should be taken into consideration in genetic and breeding studies on the improvement of yield from energy grasses of the genus *Miscanthus*.

Geothermal energy

11/02792 A quasi-steady state mathematical model of an integrated ground source heat pump for building space control

Corberan, J. M. *et al. Energy and Buildings*, 2011, 43, (1), 82–92.

This paper is concerned with the development of a mathematical model, capable of describing the quasi-steady state performance of an integrated ground source heat pump, which is used for heating and cooling of an institutional building located in a Mediterranean climate. The model is structured on functional basis according to the heat pump vapour compression or primary circuit, a secondary ground loop circuit and a secondary building loop circuit. Heat pump heating and cooling capacities, as well as COP, are considered to be dependent variables and are estimated in the model using performance fitted maps. Independent variables include: compressor speed, circulation pump speeds, ground loop return temperature and building circuit return temperature. The model is validated using data from a full-scale ground source heat pump installation. The validated model is used to examine system capacity and performance sensitivity to different control optimization strategies, including set-point control of room air temperature, room air bandwidth temperature, building loop return water temperature and building loop return bandwidth temperature.

11/02793 A renewable energy system in Frederikshavn using low-temperature geothermal energy for district heating

Østergaard, P. A. *et al. Applied Energy*, 2011, 88, (2), 479–487.

The Danish city of Frederikshavn is aiming to become a 100% renewable energy city. The city has a number of energy resources including the potential for off-shore wind power, waste and low-temperature geothermal energy usable as heat source for heat pumps producing district heating. In this article, a technical scenario is described and developed for the transition of Frederikshavn's energy supply from being predominantly fossil-fuelled to being fuelled by locally available renewable energy sources. The scenario includes all aspects of energy demand in Frederikshavn, i.e. electricity demand, heat demand, industrial demand as well as the energy demand for transportation. The locally available energy resources are deliberated and an energy system is designed and analysed with an energy systems analysis model on an aggregate annual level as well as on an hourly basis. Particular attention is given to the use of geothermal energy in the area. It is shown, that the use of geothermal energy in combination with an absorption heat pump shows promise in a situation where natural gas supply to conventional cogeneration of heat and power plants decreases radically.

11/02794 Direct utilization of geothermal energy 2010 worldwide review

Lund, J. W. *et al. Geothermics*, 2011, 40, (3), 159–180.

This paper presents a review of the worldwide application of geothermal energy for direct utilization, and updates the previous survey carried out in 2005. The authors also compare data from 1995 and 2000 presented at World Geothermal Congresses in Italy and Japan, respectively (WGC95 and WGC2000). As in previous reports, an effort is made to quantify ground-source (geothermal) heat pump data. The present report is based on country update papers prepared for WGC2010 and other sources of data available to the authors. Final update papers were received from 70 countries of which 66 reported some direct utilization of geothermal energy. Twelve additional countries were added to the list based on other sources of information. Direct utilization of geothermal energy in 78 countries is a significant increase from the 72 reported in 2005, the 58 reported in 2000, and the 28 reported in 1995. An estimate of the installed thermal power for direct utilization at the end of 2009 is used in this paper and equals 48,493 MWt, almost a 72% increase over the 2005 data, growing at a compound rate of 11.4% annually with a capacity factor of 0.28. The thermal energy used is 423,830 TJ/year (117,740 GWh/yr), about a 55% increase over 2005, growing at a compound rate of 9.2% annually. The distribution of thermal energy used by category is approximately 47.2% for ground-source heat pumps, 25.8% for bathing and swimming (including balneology), 14.9% for space heating (of which 85% is for district heating), 5.5% for greenhouses and open ground heating, 2.8% for industrial process heating, 2.7% for aquaculture pond and raceway heating, 0.4% for agricultural drying, 0.5% for snow melting and cooling, and 0.2% for other uses. Energy savings amounted to 250 million barrels (38 million tonnes) of equivalent oil annually, preventing 33 million tonnes of carbon and 107 million tonnes of CO_2 being release to the atmosphere, this includes savings for geothermal heat pumps in the cooling mode (compared to using fuel oil to generate electricity).

11/02795 Efficiency improvement of a ground coupled heat pump system from energy management

Pardo, N. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 391–398.

The installed capacity of an air conditioning system is usually higher than the average cooling or heating demand along the year. So, most of the time, the system is working under its actual capacity. This study considers the way to improve the efficiency of a ground coupled heat pump air conditioning system by adapting its produced thermal energy to the actual thermal demand. For this purpose, an air conditioning system composed by a ground coupled heat pump and a central fan coil linked to an office located in a cooling dominated area was simulated, and a new management strategy aiming to diminish electrical consumption was developed under the basic constraint that comfort requirements are kept. This strategy takes advantage of the possibility of managing the air flow in the fan, the water mass flows in the internal and external hydraulic systems, and the set point temperature in the heat pump to achieve this objective. The electrical consumption of the system is calculated for the new management strategy and compared with the results obtained for a conventional one, resulting in estimated energy savings around 30%.

11/02796 Energetic performance analysis of a ground-source heat pump system with latent heat storage for a greenhouse heating

Benli, H. *Energy Conversion and Management*, 2011, 52, (1), 581–589.

In this study, a ground-source heat pump heating system with a latent heat thermal storage tank was designed while its thermal energy storage performance was investigated. The heating system mainly consists of a ground heat exchanger, a heat pump, a cylindrical latent heat thermal storage tank, measuring units and a heating space of model-sized glass greenhouses with 30 m^2, located in the greenhouse district of Firat University, Elaziğ, in Turkey. In the experiments, the performance characteristics of a ground-source heat pump greenhouse heating system with a 246 m horizontal 12.7 mm nominal diameter horizontal closed-loop ground heat exchanger and the use of phase change materials (PCM) for energy saving and management in greenhouses were investigated. The heating coefficient of performances of the ground-source heat pump (COP_{HP}) and the overall system (COP_{sys}) are obtained, to be in the range of 2.3–3.8 and 2–3.5 respectively. Although significant savings are possible with this heating system, a substantial investment in equipment and facilities may be required. The experiments results were obtained from October to May in heating seasons of 2005–2006. The results showed that the utilization of ground-source heat pump-PCM is suitable for greenhouse heating in this district.

11/02797 Estimation of soil and grout thermal properties through a TSPEP (two-step parameter estimation procedure) applied to TRT (thermal response test) data

Bozzoli, F. *et al. Energy*, 2011, 36, (2), 839–846.

In this paper, a versatile TSPEP (two-step parameter estimation procedure) based on a three-dimensional numerical model of a geothermal system is presented. The procedure is applied to both simulated and experimental TRT (thermal response test) data in order to restore the grout and soil thermal conductivities and volumetric heat capacities. The TSPEP is essentially a two-step process. The first step uses the parameter estimation procedure, in the early transient regime to restore the grout thermal conductivity and volumetric heat capacity. The values from the first step are used as the input values in the second step, in which the parameter estimation procedure is applied to the late transient regime to restore the soil thermal conductivity and volumetric heat capacity. Further iterations of these two steps can be used to improve the accuracy of the procedure and are discussed in this paper. The time separation used between the estimation of the soil properties and the estimation of the grout properties partially uncouples the two problems and makes the estimation of these four parameters feasible. A criterion to select the time separation is discussed and validated in this paper.

11/02798 Experimental investigation of the cooling performance of a ground source heat pump system in Denizli, Turkey

Karabacak, R. *et al. International Journal of Refrigeration*, 2011, 34, (2), 454–465.

The ground source heat pump system (GSHP) is installed at Pamukkale University in Denizli, Turkey. The U-bend ground heat exchanger pipe length of 225 m was buried in soil at 110 m depth. In the 2008 cooling season, performance coefficients of the heat pump and the system were determined in the range of 3.1–4.8 and 2.1–3.1, respectively. The values of solar radiation, external temperature, relative humidity and wind speed were measured continuously. The relations of performance coefficients of ground source heat pump according to the meteorological data including solar radiation, wind speed, relative humidity and external temperature with this experiment were revealed exactly. The results of this study fulfil the lack in the literature.

11/02799 Fluid flow associated with silicic lava domes and faults, Ohaaki hydrothermal field, New Zealand

Rissmann, C. *et al. Journal of Volcanology and Geothermal Research*, 2011, 204, (1–4), 12–26.

Fault-controlled fluid flow is a well-recognized feature of hydrothermal systems. Yet, the role of extinct lava domes in governing fluid flow is less established. Here the authors present fluid-flow models for the spatial distribution and origins of permeability within the two thermal areas [Ohaaki West (OHW) and Ohaaki East (OHE)] of the Ohaaki hydrothermal field, Taupo volcanic zone (TVZ), New Zealand. The authors develop conceptual fluid-flow models using detailed mapping of surface heat and mass flow gradients and structural and volcanic/stratigraphic data. Heat and mass flow models based on extinct lava domes are of two main types: (i) a 'volcanic conduit' model where hydrothermal fluids ascending from an underlying upflow exploit remnant permeability structures associated with dome growth (dyke margins, conduit shear zones and eruptive vents) and discharge at the surface of OHW, and; (ii) a dome and regional fault, which collectively produce a channel-barrier fluid-flow system within surficial calcite-cemented alluvium and ash fall deposits that mantle the dome (OHE). These models show that silicic lava domes localize fluid flow through either remnant eruptive structures, or by providing islands of locally competent and low-porosity rock that favour the development of high-permeability fault and fracture systems. In each model, hydrothermal sealing and cementation of otherwise unconsolidated and low strength materials, mantling the domes, play an important role in permeability generation. From these observations and recent mass and heat flow surveys of other fields, they authors suggest that the Quaternary dome complexes of the TVZ, overlying long lived ($\geq$0.15–0.5 Myr) hydrothermal systems, may constitute a major pathway of magmatic heat and mass release to the atmosphere long after eruption and dome formation.

11/02800 Geothermal power production in future electricity markets – a scenario analysis for Germany

Purkus, A. and Barth, V. *Energy Policy*, 2011, 39, (1), 349–357.

Development and diffusion of new renewable energy technologies play a central role in mitigating climate change. In this context, small-scale deep geothermal power has seen growing interest in recent years as an environmentally friendly, non-intermittent energy source with large technical potential. Following the first successful demonstration projects, the German geothermal industry is currently experiencing an internationally unparalleled growth. In this study the authors explore the factors driving this development, and the role geothermal power production could play in the future of the German electricity market. For this, the authors apply the scenario technique, based on literature analysis and interviews with companies operating actively in the field. The findings highlight the importance of political support and framework conditions in the electricity market, with the best prospects in a decentralized energy system based on renewable energy sources, where high investment costs and the risk of discovery failure are balanced by the benefits of low-carbon base load power.

11/02801 Jurassic hot spring deposits of the Deseado Massif (Patagonia, Argentina): characteristics and controls on regional distribution

Guido, D. M. and Campbell, K. A. *Journal of Volcanology and Geothermal Research*, 2011, 203, (1–2), 35–47.

The Deseado Massif, Santa Cruz Province, Argentinean Patagonia, hosts numerous Middle to Late Jurassic age geothermal and epithermal features represented by siliceous and calcareous chemical precipitates from hot springs (sinters and travertines, respectively), hydrothermal breccias, quartz veins, and widespread hydrothermal silicification. They indicate pauses in explosive volcanic activity, marking the final stages in the evolution of an extensive Jurassic (ca. 178–151 Ma) volcanic complex set in a diffuse extensional back-arc setting heralding the opening of the Atlantic Ocean. Published paleo-hot spring sites for the Deseado Massif, plus additional sites identified during the recent field studies, reveal a total of 23 locations, five of which were studied in detail to determine their geologic and facies associations. They show structural, lithologic, textural and biotic similarities with Miocene to Recent hot spring systems from the Taupo and Coromandel volcanic zones, New Zealand, as well as with modern examples from Yellowstone National Park, USA. These comparisons aid in the definition of facies assemblages for Deseado Massif deposits – proximal, middle apron and distal siliceous sinter and travertine terraces and mounds, with preservation of many types of stromatolitic fabrics – that likely were controlled by formation temperature, pH, hydrodynamics and fluid compositions. Locally the mapped hot spring deposits largely occur in association with reworked volcaniclastic lacustrine and/or fluvial sediments, silicic to intermediate lava domes, and hydrothermal mineralization, all of which are related to local and regional structural lineaments. Moreover, the numerous geothermal and significant epithermal (those with published minable resources) deposits of the Deseado Massif geological province mostly occur in four regional NNW and WNW hydrothermal–structural belts (north-western, northern, central, and southern), defined here by alignment of five or more hot spring deposits and confirmed as structurally controlled by aeromagnetic data. The northern and north-western belts, in particular, concentrate most of the geothermal and epithermal occurrences. Hence, Jurassic hydrothermal fluid flow was strongly influenced by the most dominant and long-active geological boundaries in the region, the outer limits of the Deseado Massif 'horst' itself.

11/02802 Land subsidence in the Cerro Prieto geothermal field, Baja California, Mexico, from 1994 to 2005: an integrated analysis of DInSAR, leveling and geological data

Sarychikhina, O. *et al. Journal of Volcanology and Geothermal Research*, 2011, 204, (1–4), 76–90.

Cerro Prieto is the oldest and largest Mexican geothermal field in operation and has been producing electricity since 1973. The large amount of geothermal fluids extracted to supply steam to the power plants has resulted in considerable deformation in and around the field. The deformation includes land subsidence and related ground fissuring and faulting. These phenomena have produced severe damages to the local infrastructure such as roads, irrigation canals and other facilities. In this paper, the technique of differential synthetic aperture radar interferometry (DInSAR) is applied using C-band ENVISAR ASAR data acquired between 2003 and 2006 to determine the extent and amount of land subsidence in the Mexicali Valley near Cerro Prieto geothermal field. The DInSAR results were compared with published data from precise levelling surveys (1994–1997 and 1997–2006) and detailed geological information in order to improve understanding of the temporal and spatial distributions of anthropogenic subsidence in the Mexicali Valley. The levelling and DInSAR data were modelled to characterize the observed deformation in terms of fluid extraction. The results confirm that the tectonic faults control the spatial extent of the observed subsidence. These faults likely act as groundwater flow barriers for aquifers and reservoirs. The shape of the subsiding area coincides with the Cerro Prieto pull-apart basin. In addition, the changes in spatial pattern and rate of the subsidence are correlated with the development of the Cerro Prieto geothermal field.

11/02803 The geothermal project Den Haag: 3D numerical models for temperature prediction and reservoir simulation

Mottaghy, D. *et al. Geothermics*, 2011, 40, (3), 199–210.

The proposed Den Haag Zuidwest district heating system of the city of The Hague consists of a deep doublet in a Jurassic sandstone layer that is designed for a production temperature of 75 °C and a reinjection temperature of 40 °C at a flow rate of 150 $m^3 h^{-1}$. The prediction of reservoir temperature and production behaviour is crucial for success of the proposed geothermal doublet. This work presents the results of a study of the important geothermal and geohydrological issues for the doublet design. In the first phase of the study, the influences of the three-dimensional (3D) structures of anticlines and synclines on the temperature field were examined. A comprehensive petrophysical investigation was performed to build a large scale 3D-model of the reservoir. Several bottomhole temperatures (BHTs), as well as petrophysical logs were used to calibrate the model using thermal conductivity measurements on 50 samples from boreholes in different lithological units in the study area. Profiles and cross sections extracted from the calculated temperature field were used to study the temperature in the surrounding areas of the planned doublet. In the second phase of the project, a detailed 3D numerical reservoir model was set up, with the aim of predicting the evolution of the producer and injector temperatures, and the extent of the cooled area around the injector. The temperature model from the first phase provided the boundary conditions for the reservoir model. Hydraulic parameters for the target horizons, such as porosity and permeability, were taken from data available from the nearby exploration wells. The simulation results are encouraging as no significant thermal breakthrough is predicted. For the originally planned location of the producer, the extracted water temperature is predicted to be around 79 °C, with an almost negligible cooling in the first 50 years of production. When the producer is located shallower parts of the reservoir, the yield water temperatures is lower, starting at ≈76 °C and decreasing to ≈74 °C after 50 years of operation. This comparatively larger decrease in temperature with time is caused by the structural feature of the reservoir, namely a higher dip causes the cooler water to easily move downward. In view of the poor reservoir data, the reservoir simulation model is constructed to allow iterative updates using data assimilation during planned drilling, testing, and production phases. Measurements during an 8 h pumping test carried out in late 2010 suggest that a flow rate of 150 $m^3 h^{-1}$ is achievable. Fluid temperatures of 76.5 °C were measured, which is very close to the predicted value.

11/02804 Thermodynamic and thermoeconomic optimization of a cooling tower-assisted ground source heat pump

Sayyadi, H. and Nejatolahi, M. *Geothermics*, 2011, 40, (3), 221–232.

Thermodynamic and thermoeconomic optimization of a cooling tower-assisted ground source heat pump (GSHP) in a multi-objective optimization process is performed. A thermodynamic model based on energy and exergy analyses is presented, and an economic model of the hybrid GSHP (HGSHP) system is developed according to the total revenue requirement (TRR) method. The proposed hybrid cooling tower-assisted GSHP system, including 12 decision variables, is considered for optimization. Three optimization scenarios, including thermodynamic single objective, thermoeconomic single objective, and multi-objective optimizations, are performed. In multi-objective optimization, both thermodynamic and thermoeconomic objectives are simultaneously considered. An optimization process is performed using the genetic algorithm. In the case of multi-objective optimization, an example of a decision-making process for selection of the final solution from the Pareto optimal frontier is presented. The results obtained using the various optimization approaches are compared and discussed. Further, the sensitivity of optimized systems to the interest rate, the annual number of operating hours in cooling mode, the electricity price, and the water price are studied in detail. It is shown that the thermodynamic optimization is focused on provision for the limited source of energy, whereas the thermoeconomic optimization only focuses on monetary resources. In contrast, the multi-objective optimization considers both energy and monetary. Further, it is found that thermodynamic optimization is economical when the operating time in cooling mode is long and/or the electricity price is high, and water prices variations have no marked impact on the total product cost.

11/02805 Two-dimensional resistivity imaging in the Kizildere geothermal field by MT and DC methods

Bayrak, M. *Journal of Volcanology and Geothermal Research*, 2011, 204, (1–4), 1–11.

Magnetotelluric (MT) and Schlumberger (DC) surveys were conducted to identify conductive zones inside metamorphic complex in the easternmost part of B. Menderes Graben. In this study, using these surveying data, creation of some two-dimensional images of the shallow and deeper parts of the area was aimed. Broadband (200–0.002 Hz) MT and Schlumberger data were acquired along four profiles crossing the B. Menderes Graben with a total of 18 MT and 19 DC stations. These data were modelled using two-dimensional inverse techniques. The main findings are: (1) presence of wide conductive regions with very low resistivity (<3 Ω m) are imaged at depth of approximately 100 m, extending to maximum approximately 2000 m depth, and these conductive regions signify potential geothermal resource in the area, (2) presence of deep conductive regions (< 75 Ω m) at a depth from approximately 15 to 35 km, which reflects the shallow asthenosphere, could be correlated with the presence of high enthalpy geothermal system and its heat source.

11/02806 Year round experimental study on a constant temperature and humidity air-conditioning system driven by ground source heat pump

Yu, X. *et al. Energy*, 2011, 36, (2), 1309–1318.

Numerous studies about the ground source heat pump (GSHP) building heating and cooling systems have been conducted in office buildings, hotels, residential buildings, schools, and so on. However, few researches about the constant temperature and humidity air-conditioning system driven by ground-coupled heat pumps have carried out. In this paper, a constant temperature and humidity air-conditioning system driven by a ground source heat pump was designed and constructed in an archives building in Shanghai, China. During the operation in the cooling mode, the heat extraction from the condenser of the heat pump was divided: part was lost to the soil while the rest reheated the air in air handling units. According to the experimental results, the indoor temperature and relative humidity fulfilled the 'Archives Design Code'. In summer, the heat lost to the soil was reduced by 32%, which was helpful for energy conservation. The soil temperature increased only 0.5 °C after the GSHP system operating for a year. The energy cost of the air-conditioning system was 56.1 kWh/m^2. Compared with the air source heat pump system and the water cooled unit with boiler system, the operating cost of the ground source heat pump was reduced by 55.8% and 48.4%, respectively.

Solar energy

11/02807 A comparative study on the performance of photogalvanic cells with different photosensitizers for solar energy conversion and storage: d-xylose–NaLS systems

Bhimwal, M. K. and Gangotri, K. M. *Energy*, 2011, 36, (2), 1324–1331.

The comparative performance of photogalvanic cells has been studied for solar energy conversion and storage by using methyl orange, rose bengal, toluidine blue and brilliant cresyl blue as different photosensitizers with d-xylose as reductant and sodium lauryl sulfate (NaLS) as surfactant in the different systems. The photogeneration of photopotential are 890.0, 885.0, 945.0 and 940.0 mV whereas the maximum photocurrent is 625.0, 575.0, 510.0 and 480.0 μA, respectively. The short circuit current or photocurrent at equilibrium is 480.0, 460.0, 430.0 and 440.0 μA, respectively. The observed conversion efficiencies for methyl orange, rose bengal, toluidine blue and brilliant cresyl blue with d-xylose and sodium lauryl sulfate systems are 1.6245, 1.5261, 1.4323 and 1.1057%, respectively. The fill factors 0.3244, 0.3151, 0.3120, and 0.2408 are experimentally determined at the power point of the cell where the absolute value is 1.0. The photogalvanic cells so developed can work for 160.0, 145.0, 130.0 and 140.0 min in dark if it is irradiated for 180.0, 165.0, 135.0 and 150.0 min, respectively where the percentage of storage capacity of photogalvanic cells are found 87.87%–96.29%. All observed results are the higher among the reported results so far in the literature.

11/02808 A new trough solar concentrator and its performance analysis

Tao, T. *et al. Solar Energy*, 2011, 85, (1), 198–207.

The operation principle and design method of a new trough solar concentrator is presented in this paper. Some important design parameters about the concentrator are analysed and optimized. Their magnitude ranges are given. Some characteristic parameters about the concentrator are compared with that of the conventional parabolic trough solar concentrator. The factors having influence on the performance of the unit are discussed. It is indicated through the analysis that the new trough solar concentrator can actualize reflection focusing for the sun light using multiple curved surface compound method. It also has the advantages of improving the work performance and environment of high-temperature solar absorber and enhancing the configuration intensity of the reflection surface.

11/02809 An automotive thermoelectric–photovoltaic hybrid energy system using maximum power point tracking

Zhang, X. and Chau, K. T. *Energy Conversion and Management*, 2011, 52, (1), 641–647.

In recent years, there has been active research on exhaust gas waste heat energy recovery for automobiles. Meanwhile, the use of solar energy is also proposed to promote on-board renewable energy and hence to improve their fuel economy. In this paper, a new thermoelectric–photovoltaic (TE–PV) hybrid energy system is proposed and implemented for automobiles. The key is to newly develop the power conditioning circuit using maximum power point tracking so that the output power of the proposed TE–PV hybrid energy system can be maximized. An experimental system is prototyped and tested to verify the validity of the proposed system.

11/02810 An efficient way to use medium-or-low temperature solar heat for power generation – integration into conventional power plant

Yang, Y. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 157–162.

This paper demonstrates that the medium-or-low temperature solar heat can be used to generate power efficiently by integrating into conventional coal-fired power plants. In so-called solar-aided power generation (SAPG) technology, medium-or-low temperature solar heat is used to replace parts of bled-off steams in regenerative Rankine cycle to pre-heat feedwater. Thermal oil can be used as solar heat carrier and no solar steam needs to be generated, therefore the pressure of solar system can be much lower than that of the solar collector using water/steam as the heat carrier. A 200 MW coal-fired thermal power plant is selected as the case study to demonstrate the advantages of the SAPG technology in terms of solar to power efficiency, specific fuel and steam consumption rates, under various integration scenarios. The results indicate that there is a great potential and effect for low or medium solar heat to be used for power generation purposes through SAPG approach.

11/02811 An estimation of the performance limits and improvement of dry cooling on trough solar thermal plants

Deng, H. and Boehm, R. F. *Applied Energy*, 2011, 88, (1), 216–223.

A study is reported of the potential performance of dry cooling on power generation. This is done in the context of a generic trough solar thermal power plant. The commercial power plant analysis code GateCycle is applied for this purpose. This code is used to estimate typical performance of both wet and dry cooling options. Then it is configured to estimate the performance of ideal wet and dry cooling options. The latter are defined as the condenser temperature being at the ambient wet bulb temperature or dry bulb temperature, respectively. Yearly power production of a solar power plant located in Las Vegas is presented for each of the cooling options. To move further toward approaching the possible improvement in dry cooling, the impact of a high-performance heat exchanger surface is evaluated. From this it is found that higher efficiency generation compared to current dry cooling designs is definitely possible. In fact the performance of these types of systems can approach that of wet cooling system units.

11/02812 Cadmium sulfide enhances solar cell efficiency

Böer, K. W. *Energy Conversion and Management*, 2011, 52, (1), 426–430.

A thin layer of CdS of about 200 Å enhances the solar conversion efficiency of CdS/CdTe solar cells from 8% to 15%. A similar enhancement of the efficiency is observed on other solar cells, based on CuInSe$_2$ or similar compounds. The reason for this efficiency enhancement that is typical for CdS, but not observed with similar semiconductors, is briefly described. The technical and economical importance of these solar cells on the energy conversion market is summarized.

11/02813 Characterizations and photocatalytic activity comparisons of N-doped nc-TiO$_2$ depending on synthetic conditions and structural differences of amine sources

Diker, H. *et al. Energy*, 2011, 36, (2), 1243–1254.

N-doped TiO$_2$ nanoparticles were prepared by using 1° and 2° alkyl and alcohol amines [n-propylamine (nPRYL), ethanolamine (ETOH), propanolamine (PROH), diethylamine (DETYL), dipropylamine (DPRYL), diethanolamine (DETOH), and ammonium hydroxide (NH$_4$OH)] as nitrogen sources through microwave and hydrothermal growth (HT) methods. Characterization of the nanoparticles was done by X-ray diffraction, scanning electron microscopy, ultraviolet–visible absorption spectra, X-ray photoelectron spectroscopy, fourier transform infrared spectroscopy and BET analysis techniques. Nitrogen species in TiO$_2$ lattice were interstitial impurities. Nitrogen content of the particles depended on the preparation conditions and structural differences of nitrogen sources. Photocatalytic degradation of methylene blue was carried out under Xenon lamp irradiation. N-doped TiO$_2$ nanoparticles exhibited higher photocatalytic activity, compared to undoped ones. Acidity differences of amine sources and irradiation differences of synthetic conditions had an effect on photocatalytic activity. Although N doping into TiO$_2$ lattice was the least effective in the particle prepared by the use of nPRYL as the amine source and HT as the synthetic condition, its photocatalytic activity was slightly better compared to others.

11/02814 Collector efficiency of upward-type double-pass solar air heaters with fins attached

Ho, C.-D. *et al. International Communications in Heat and Mass Transfer*, 2011, 38, (1), 49–56.

The collector efficiency of upward-type double-pass flat plate solar air heaters with fins attached and external recycle is investigated theoretically. The double-pass device was constructed by inserting the absorbing plate into the air conduit to divide it into two channels (the upper and lower channels). The double-pass device introduced here was designed for creating a solar collector with heat transfer area double as well as the extended area of fins between the absorbing plate and heated air. Moreover, the advantage of external recycle application to solar air heaters is the enhancement of forced heat convection strength, resulting in considerable device heat transfer performance improvement. This advantage may compensate for the remixing at the inlet which decreases the heat transfer transfer-driving force decrement (temperature difference).

11/02815 Estimation of global solar irradiation on horizontal and inclined surfaces based on the horizontal measurements

Muzathik, A. M. *et al. Energy*, 2011, 36, (2), 812–818.

Solar radiation data are essential in the design of solar energy conversion devices. In this regard, empirical models were selected to estimate the global solar radiation on horizontal and inclined surfaces. The hourly solar radiation data measured at the study area during the period of 2004–2007, were used to calculate solar radiations using selected models. The selected models were compared on the basis of statistical methods. Based on the results, a new model, $H/H_o = 0.19490 + 0.4771(n/N) + 0.02994\ \exp(n/N)$ has been developed, based on Kadir Bakirci linear exponential model. This is highly recommended to estimate monthly mean daily global solar irradiation, on a horizontal surface. Further, a model to convert horizontal solar global radiation to that of radiation on a tilted surface is also presented. It is based upon a relatively simple model which requires only measurements of horizontal solar radiation. The developed model appears to give excellent results and has the advantage of being relatively simple for applications. The present work will help to improve the state of knowledge of global solar radiation to the point where it has applications in the estimation of global solar radiation, both on horizontal and inclined surfaces.

11/02816 Estimation of monthly solar radiation distribution for solar energy system analysis

Coskun, C. *et al. Energy*, 2011, 36, (2), 1319–1323.

The concept of probability density frequency, which is successfully used for analyses of wind speed and outdoor temperature distributions, is now modified and proposed for estimating solar radiation distributions for design and analysis of solar energy systems. In this study, global solar radiation distribution is comprehensively analysed for photovoltaic (PV) panel and thermal collector systems. In this regard, a case study is conducted with actual global solar irradiation data of the last 15 years recorded by the Turkish State Meteorological Service. From this it is found that intensity of global solar irradiance greatly affects energy and exergy efficiencies and hence the performance of collectors.

11/02817 Evaluation of systems coupling vacuum membrane distillation and solar energy for seawater desalination

Mericq, J.-P. *et al. Chemical Engineering Journal*, 2011, 166, (2), 596–606.

Vacuum membrane distillation (VMD) is a hybrid membrane-evaporative process which has been shown to be of interest for seawater desalination. The main drawback of this process is the relatively high energy requirement linked to the need to heat the feed water. A way to solve this problem could be the use of a renewable source such as solar energy to provide the heat energy required. Two solutions of solar energy use are investigated in this paper: salinity gradient solar ponds (SGSP) and solar collectors. For each solution, two configurations were studied. The first was based on preheating the feed seawater before the membrane process while the second used a membrane module directly coupled with solar energy, i.e. a membrane submerged in an SGSP or a solar collector integrated at the surface of the membrane module. VMD process simulations were carried out for the four different configurations with VMD modelling software previously developed and adapted to the different combinations. Simulation results showed that immersing the membrane module directly in an SGSP could induce marked concentration and temperature polarization phenomena that reduced fluxes. Turbulence had to be created in the feed seawater to reduce polarizations and this option was difficult to combine with an SGSP. The most interesting solution seemed to be the use of solar collectors. High fluxes of $140\,\mathrm{L\,h^{-1}\,m^{-2}}$ could be reached (for a vacuum pressure of 500 Pa and a membrane with a Knudsen permeability of $1.85 \times 10^{-5}\,\mathrm{s\ mol^{1/2}\,m^{-1}\,kg^{-1/2}}$).

11/02818 Experimental validation of dynamic simulation of the flat plate collector in a closed thermosyphon solar water heater

Taherian, H. *et al. Energy Conversion and Management*, 2011, 52, (1), 301–307.

This work studies the dynamic simulation of thermosyphon solar water heater collector considering the weather conditions of a city in north of Iran. The simulation was done for clear and partly cloudy days. The useful energy, the efficiency diagrams, the inlet and the outlet of collector, centre of the absorber and centre of the glass cover temperatures, were obtained. The simulation results were then compared with the experimental results in fall and showed a good agreement.

11/02819 Financing concentrating solar power in the Middle East and North Africa – subsidy or investment?

Trieb, F. *et al. Energy Policy*, 2011, 39, (1), 307–317.

The paper presents a strategy for the market introduction of concentrating solar power (CSP) plants in the Middle East and North Africa (MENA) that will not require considerable subsidization and will not constitute a significant burden for electricity consumers in the region. In the first section, the paper explains the need of MENA countries for sustainable supply of electricity and calculates the cost of electricity for a model case country. In the second part, the cost development of concentrating solar power plants is calculated on the basis of expectations for the expansion of CSP on a global level. After that, the challenges for the market introduction of CSP in MENA are explained. Finally, the authors present a strategy for the market introduction of CSP in MENA, removing the main barriers for financing and starting market introduction in the peak load and the medium load segment of power supply. The paper explains why long-term power purchase agreements (PPA) for CSP should be calculated on the basis of avoided costs, starting in the peak load segment. Such PPA are not yet available, the paper aims to convince policy makers to introduce them.

11/02820 Hydrogen peroxide automatic dosing based on dissolved oxygen concentration during solar photo-Fenton

Prieto-Rodríguez, L. *et al. Catalysis Today*, 2011, 161, (1), 247–254.

Nowadays the potential of photo-Fenton process for decontamination of biologically persistent wastewater is widely recognized. In this process, hydrogen peroxide consumption could be considered as one of the factors that considerably affects costs. This highlights that an automatically hydrogen peroxide dosing system to keep the concentration optimized throughout the process would be a valuable tool for industrial wastewater remediation plants. Automatic H_2O_2 dosing during photo-Fenton would require a precise online measuring device. Today, several expensive and unreliable in complicated wastewater hydrogen peroxide probes are commercially available. This study focuses on considering dissolved oxygen concentration (DO) as a reaction stage indicator related to H_2O_2 concentration and consumption during photo-Fenton wastewater treatment. First, specific experiments designed to find out the DO–H_2O_2 related behaviour during photo-Fenton at different possible operating conditions were carried out with manual addition of H_2O_2. Afterwards, a following set of experiments was performed with automatic H_2O_2 dosing according to DO concentration maintaining this parameter between desirable set points during the photo-Fenton reaction. The obtained results demonstrated the potential for making use of the DO profile for monitoring photo-Fenton, automatically dosing H_2O_2 and determining the end point of the treatment. The active participation of oxygen in the first stages of the process by Dorfman-mechanism was confirmed.

11/02821 Improvement of temperature-based ANN models for solar radiation estimation through exogenous data assistance

Martí, P. and Gasque, M. *Energy Conversion and Management*, 2011, 52, (2), 990–1003.

The development of new and more precise temperature-based models for solar radiation estimation is decisive, given the immediacy and simplicity associated to their input measurements and the ubiquitous problems derived from equipment failures, maintenance and calibration, and physical and biological constraints. Further, the performance quality of empirical equations is to be questioned in a large variety of climatic contexts. As an alternative to traditional techniques, artificial neural networks (ANNs) are highly appropriate for the modelling of non-linear processes. Nevertheless, temperature-based ANN models do not always provide accurate enough solar radiation estimations as their performance depends considerably on the specific temperature/solar radiation relationships of the studied context. This paper describes a new procedure to improve the performance accuracy of temperature-based ANN models for estimation of total solar radiation on a horizontal surface (R_s) taking advantage of ancillary data records from secondary similar stations, which work as exogenous inputs. The influence on the model performance of the number of considered ancillary stations and the corresponding number of training patterns is also analysed. Finally, these models are compared with those relying exclusively on local temperature recordings. The proposed models provide performances with lower associated errors than those which do not consider exogenous inputs. The ancillary supply is translated into a decrease around 0.1 of RMSE in the local performance. The consideration of non-measured inputs in the simple local temperature-based models, namely extraterrestrial radiation or day of the year, entails a performance accuracy improvement around 0.1 of RMSE.

11/02822 Increasing the solar photovoltaic energy capture on sunny and cloudy days

Kelly, N. A. and Gibson, T. L. *Solar Energy*, 2011, 85, (1), 111–125.

This report analyses an extensive set of measurements of the solar irradiance made using four identical solar arrays and associated solar sensors (collectively referred to as solar collectors) with different tilt angles relative to the earth's surface, and thus the position of the sun, in order to determine an optimal tracking algorithm for capturing solar radiation. The study found that on sunny days, solar collectors with a directly toward the sun (DTS) configuration captured more solar energy in accordance with the well-known cosine dependence for the response of a flat-surfaced solar collector to the angle of incidence with direct beam radiation. In particular, a DTS orientation was found to capture up to twice as much solar energy as a horizontal (H) orientation in which the array is tilted toward the zenith. Another set of solar collectors always had an H orientation, and this best captured the diffuse component of the solar radiation that predominates on cloudy days. The dependence of the H/DTS ratio on the solar-collector tilt angle was in approximate agreement with the isotropic diffuse model derived for heavily overcast conditions. During cloudy periods, the authors found that an H configuration increased the solar energy capture by nearly 40% compared to a DTS configuration during the same period, and estimate the solar energy increase of an H configuration over a system that tracks the obscured solar disk could reach 50% over a whole heavily-overcast day. On an annual basis the increase is predicted to be much less, typically only about 1%, because the contribution of cloudy days to the total annual solar energy captured by a photovoltaic system is small. These results are consistent with the solar tracking algorithm optimized for cloudy conditions that was proposed in an earlier report and that was based on a much smaller data set. Improving the harvesting of solar energy on cloudy days deserves wider attention due to increasing efforts to utilize renewable solar energy. In particular, increasing the output of distributed solar power systems on cloudy days is important to developing solar-powered home fuelling and charging systems for hydrogen-powered fuel-cell electric and battery-powered vehicles, respectively, because it reduces the system size and cost for solar power systems that are designed to have sufficient energy output on the worst (cloudy) days.

11/02823 Innovation and international technology transfer: the case of the Chinese photovoltaic industry

de la Tour, A. *et al. Energy Policy*, 2011, 39, (2), 761–770.

China is the largest solar photovoltaic cell producer in the world, with more than one-third of worldwide production in 2008, exporting more than 95% of what it produces. The purpose of this paper is to understand the drivers of this success and its limits, with a particular emphasis on the role of technology transfers and innovation. This analysis combines a review of international patent data at a detailed technology level with field interviews of 10 Chinese PV companies. The authors show that Chinese producers have acquired the technologies and skills necessary to produce PV products through two main channels: the purchasing of manufacturing equipment in a competitive international market and the recruitment of skilled executives from the Chinese diaspora who built pioneer PV firms. The success of these firms in their market is, however, not reflected in their performance in terms of innovation. Rather, patent data highlight a policy-driven effort to catch up in critical technological areas.

11/02824 Investigation of the behavior of a three phase grid-connected photovoltaic system to control active and reactive power

Tsengenes, G. and Adamidis, G. *Electric Power Systems Research*, 2011, 81, (1), 177–184.

In this paper, a photovoltaic (PV) system, with maximum power point tracking (MPPT), connected to a three-phase grid is presented. The connection of photovoltaic system on the grid takes place in one stage using voltage source inverter (VSI). For a better utilization of the photovoltaic system, the control strategy applied is based on p–q theory. According to this strategy during sunlight the system sends active power to the grid and at the same time compensates the reactive power of the load. In case there is no sunlight (during the night for instance), the inverter only compensates the reactive power of the load. In this paper the use of p–q theory to supply the grid with active power and compensate the reactive power of the load is investigated. The advantage of this control strategy is that the photovoltaic system is operated the whole day. Furthermore, the p–q theory uses simple algebraic calculations without demanding the use of PLL to synchronize the inverter with the grid.

11/02825 Investigation of thermal performance of-double pass-flat and v-corrugated plate solar air heaters

El-Sebaii, A. A. *et al. Energy*, 2011, 36, (2), 1076–1086.

In this paper, the double pass flat and v-corrugated plate solar air heaters are investigated theoretically and experimentally. Analytical models for the air heater with flat and v-corrugated plates are presented. Numerical calculations have been performed under Tanta (latitude, 30°47′N) prevailing weather conditions. The theoretical predictions indicated that the agreement with the measured performance is fairly good. Comparisons between the measured outlet temperatures of flowing air, output power and overall heat losses of the flat and v-corrugated plate solar air heaters are also presented. The effect of mass flow rates of air on pressure drop, thermal and thermo hydraulic efficiencies of the flat and v-corrugated plate solar air heaters are also investigated. The results showed that the double pass v-corrugated plate solar air heater is 11–14% more efficient compared to the double pass flat plate solar air heater. It is also indicated that the peak values of the thermo hydraulic efficiencies of the flat and v-corrugated plate solar air heaters are obtained when the mass flow rate of the flowing air is 0.02 kg/s.

11/02826 Modeling and experimental validation of the solar loop for absorption solar cooling system using double-glazed collectors

Marc, O. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 268–277.

Solar cooling applied to buildings is without a doubt an interesting alternative for reducing energy consumption in traditional mechanical steam compression air conditioning systems. The study of these systems should have a closely purely fundamental approach including the development of numerical models in order to predict the overall installation performance. The final objective is to estimate cooling capacity, power consumption, and overall installation performance with relation to outside factors (solar irradiation, outside temperature, etc.). The first stage in this work consists of estimating the primary energy produced by the solar collector field. The estimation of this primary energy is crucial to ensure the evaluation of the cooling capacity and therefore the cooling distribution and thermal comfort in the building. Indeed, the absorption chiller performance is directly related to its heat source. This study presents dynamic models for double glazing solar collectors and compares the results of the simulation with experimental results taken from the test bench (two collectors). In the second part, the authors present an extensive collector field model (36 collectors) from the solar cooling installation at the University Institute of Technology in St Pierre, Reunion Island as well as their stratified tank storage model. A comparison of the simulation results with real scale solar experimental data taken from the installation enables validation of the double glazing solar collector and stratified tank dynamic models.

11/02827 New control paradigm for integration of photovoltaic energy sources with utility network

Sait, H. H. and Daniel, S. A. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (1), 86–93.

The employment of an inverter to integrate a distributed generation system to the utility network is well known. In such a context, there is an increasing interest in developing an appropriate control strategy to derive a current with less distortion from the inverter. In this paper, a new current controller for inverters of this kind has been proposed. The proposed technique combines the benefits of a proportional–integral controller and a hysteresis limiter. The paper presents the development of such a controller and its structure. Inverter-output current waveforms of the proposed scheme are compared with that of a hysteresis alone and average current mode controllers. A better harmonic elimination and current tracking performance of the proposed controller is thereby established. Filter responses have also been compared to establish the superiority of the proposed approach.

11/02828 Numerical simulation of a solar-assisted ejector air conditioning system with cold storage

Diaconu, B. M. *et al. Energy*, 2011, 36, (2), 1280–1291.

Indoor space cooling represents a large potential for solar energy use due to the relative coincidence between energy availability and cooling demand. Solar-assisted air conditioning (AC) applications emerged with the development of high-efficiency solar collectors. Energy storage (hot or cold) must be implemented for solar-assisted AC applications when cooling demand is present during intervals without available solar energy and also for cooling capacity optimization ('peak shaving'). The present paper analyses a solar-assisted ejector cooling system with cold storage. Simulations were carried out over 1 year considering climatic data for a hot location (Béchar, Algeria) and the performance of the system was assessed for a set of design conditions. Effects of cold storage upon comfort conditions and energy demand were evaluated. Maximum room temperature and overall interval of time during which the room temperature exceeded the set-point value were the parameters used to quantify system performance. It was found that cold storage improved comfort conditions compared to a system without storage. For some design conditions it was found that increasing the cold storage capacity did not result in improved comfort conditions. The control algorithm of the system was identified as the cause of this behaviour.

11/02829 One-dimensional model of solar thermal reactors for the co-production of hydrogen and carbon black from methane decomposition

Patrianakos, G. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 189–202.

The solar thermal decomposition of methane is a promising route for the large scale production of hydrogen and carbon black with zero CO_2 emissions, however careful control of the reactor is required to ensure product particles of specific sizes. A one-dimensional model employing a sectional method is developed to simulate the evolution of polydisperse fresh and seed particle populations in an indirectly heated solar reactor. The model accounts for the homogeneous nucleation of fresh particles, the heterogeneous growth of the fresh and seed particles, particle coagulation, and the growth of carbon on the walls of the reactor from heterogeneous reaction and particle deposition. The heat transport mechanisms modelled include wall–gas convection, wall–particle radiation exchange, particle–gas convection and heat release from chemical reaction. The model is validated in terms of methane conversion against a 10 kW experimental solar reactor and used to extract kinetic parameters for the homogeneous and heterogeneous reaction paths. The model shows promise as a quick and simple tool for the design and control of industrial scale solar reactors.

11/02830 Optical performance of inclined south–north axis three-positions tracked solar panels

Zhong, H. *et al. Energy*, 2011, 36, (2), 1171–1179.

In this work, the optical performance of solar panels with a new sun-tracking technique was theoretically investigated based on the proposed mathematical method and monthly horizontal radiation. The mechanism of the investigated sun-tracking is that the attitude angle of solar panels is daily adjusted three times at three fixed positions: eastward, southward, and westward in the morning, noon, and afternoon, respectively, by rotating solar panels about the inclined south–north axis (ISNA-3P sun-tracking). Calculation results showed that, for ISNA-3P tracked solar panels with a yearly fixed tilt-angle of the ISNA, the maximum annual collectible radiation on ISNA-3P tracked solar panels was about 93% of that on a solar panel with 2-axis sun-tracking; whereas for those with the ISNA being yearly adjusted four times at three fixed tilt-angles, it was about 96%. Results also indicated that the attempt to further increase the annual solar gain on ISNA-3P tracked solar panels by seasonally optimizing design of the sun-tracking system for maximizing solar gain in each of four seasons was not efficient, and thus not advisable in practical applications. Optimal parametric designs of such sun-tracking system for maximizing the annual solar gain on solar panels in different cases were also presented.

11/02831 Performance investigation of a salt gradient solar pond coupled with desalination facility near the Dead Sea

Saleh, A. *et al. Energy*, 2011, 36, (2), 922–931.

Solar ponds provide the most convenient and least expensive option for heat storage for daily and seasonal cycles. This is particularly important for a desalination facility, if steady and constant water production is required. If, in addition to high storage capacity, other favourable conditions exist, the salt gradient solar ponds (SGSPs) are expected to be able to carry the entire load of a large-scale flash desalination plants without dependence upon supplementary sources. This paper presents a performance investigation of a SGSP coupled with desalination plant under Jordanian climatic conditions. This is particularly convenient in the Dead Sea region characterized by high solar radiation intensities, high ambient temperature most of the year, and by the availability of high concentration brine. It was found that a $3000\,m^2$ solar pond installed near the Dead Sea is able to provide an annual average production rate of $4.3\,L\,min^{-1}$ distilled water compared with $3.3\,L\,min^{-1}$ that would be produced by El Paso solar pond, which has the same surface area. Based on this study, solar ponds appear to be a feasible and an appropriate technology for water desalination near the Dead Sea in Jordan.

11/02832 Performance study of the inverted absorber solar still with water depth and total dissolved solid

Dev, R. *et al. Applied Energy*, 2011, 88, (1), 252–264.

In this communication, an experimental study of inverted absorber solar still (IASS) and single slope solar still (SS) at different water depth and total dissolved solid (TDS) is presented. Experiments are conducted for the climatic condition of Muscat, Oman. A thermal model is also developed for the IASS and validated with experimental results. A fair agreement is found for the daytime operation of the IASS. It is observed that higher water temperature can be achieved by using the IASS in comparison to the SS. The daily yield obtained from the IASS are 6.302, 5.576 and 4.299 kg/m^2-day at water depths (d_w) 0.01, 0.02 and 0.03 m respectively. At same respective water depths, the daily yield obtained from the SS are 2.152, 1.931, 0.826 kg/m^2-day respectively lower than that of the IASS. It is observed that for climatic condition of Muscat, Oman, the optimum water depth for the IASS is 0.03 m above which the addition of reflector under the basin does not affect its performance much more in comparison to that of the SS for sea water. The feed saline water and yielded distilled water are also compared for different TDS values, pH, and electrical conductance. On the basis of economic analysis of IASS, it is found that the annualized cost of distilled water in Indian rupees for Muscat climatic condition is Rs. 0.74, 0.66 and 0.62 (conversion factors: \$1 = Rs. 50 and 1 OMR = Rs. 120) for the life time of 15, 20 and 25 years, respectively.

11/02833 Photogalvanic conversion of solar energy into electrical energy by using NaLS–xylose–methylene blue system

Bhati, K. K. and Gangotri, K. M. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (2), 155–158.

Photogalvanic cells having different surfactants, reductants and photosensitizers have been tried to get the better electrical output and storage capacity. Through literature survey shows that system having NaLS as a surfactant, xylose as a reductant and methylene blue as a photosensitizer has not been explored to get the required results and achievements so the efforts have been made by the system in photogalvanic cell to get better electrical output (i.e. photopotential 834 mV, photocurrent 90 μA, power and power at power point are 75.06 μW and 32.72 μW) and also good storage capacity, i.e. 55 min in dark. The observed conversion efficiency and fill factor for this is 0.31%, 0.363%. The effect of different parameter like pH, diffusion length on electrical output of the cell was also studied and tentative mechanism for the generation of photocurrent was also purposed.

11/02834 Rural electrification in India and feasibility of photovoltaic solar home systems

Kamalapur, G. D. and Udaykumar, R. Y. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 594–599.

Rural electrification is an integral component of poverty alleviation and rural growth of a nation. In India, electricity has not played effective role in the socio-economic growth of village. Gross domestic product (GDP) is increasing with 8% where as contribution of agriculture sector is 1.9%. India's government has ambitious target of providing electricity to all villages by 2008 and all rural households by 2012. Steps are already initiated with Rural Electric Corporation, Rural Electricity Supply Technology mission, State Electricity Boards, Reforms in Power sector. An attempt has been made in this paper to assess the features of rural electrification in India and the feasibility of photovoltaic solar home systems.

11/02835 Solar control: a general method for modelling of solar gains through complex facades in building simulation programs

Kuhn, T. E. *et al. Energy and Buildings*, 2011, 43, (1), 19–27.

This paper describes a new general method for building simulation programs which is intended to be used for the modelling of complex facades. The term 'complex facades' is used to designate facades with venetian blinds, prismatic layers, light re-directing surfaces, etc. In all these cases, the facade properties have a complex angular dependence. In addition to this, such facades very often have non-airtight layers and/or imperfect components (e.g. non-ideal sharp edges, non-flat surfaces, etc.). Therefore building planners often had to neglect some of the innovative features and to use 'work-arounds' in order to approximate the properties of complex facades in building simulation programs. A well-defined methodology for these cases was missing. This paper presents such a general methodology. The main advantage of the new method is that it only uses measureable quantities of the transparent or translucent part of the facade as a whole. This is the main difference in comparison with state of the art modelling based on the characteristics of the individual subcomponents, which is often impossible due to non-existing heat- and/or light-transfer models within the complex facade. It is shown that the new method can significantly increase the accuracy of heating/cooling loads and room temperatures.

11/02836 Solar linear Fresnel collector using molten nitrates as heat transfer fluid

Grena, R. and Tarquini, P. *Energy*, 2011, 36, (2), 1048–1056.

The use of molten nitrates as heat transfer fluid in a solar Fresnel linear concentrator is proposed. A system specifically designed to work with molten nitrates is presented, with an analysis of its optical and thermal properties and the discussion of advantages and disadvantages with respect to existing systems.

11/02837 Solar photocatalysis as a tertiary treatment to remove emerging pollutants from wastewater treatment plant effluents

Bernabeu, A. *et al. Catalysis Today*, 2011, 161, (1), 235–240.

Water taken from the outlet of a wastewater treatment plant from the south-east of Spain has been treated by means of TiO_2-based solar photocatalysis. Preliminary analysis showed the presence of significant amounts of nine emerging pollutants (order of magnitude of ng/l): trimethoprim, ofloxacin, enrofloxacin, clarithromycin, acetaminophen, diclofenac, caffeine, thiabendazole and carbamazepine; and trace amounts of another two were detected, namely acetamiprid and erythromycin. Irradiation of the effluent in the presence of TiO_2 resulted in a significant removal of all the emerging pollutants, as most of them were detected only at trace amounts after the treatment. In addition to this, percentages of faecal bacteria elimination were close to 100%. Finally, experiments carried out using caffeine as model compound showed that a mild photo-Fenton process might be employed at neutral media in the presence of humic acids, although the performance was worse than photo-Fenton at acidic pH or TiO_2.

11/02838 Stationary analysis of a solar LiBr–H_2O absorption refrigeration system

Monné, C. *et al. International Journal of Refrigeration*, 2011, 34, (2), 518–526.

The present work describes the operation of a solar-powered absorption cooling system. This solar cooling installation was designed in order to resolve the overheating problems of an existing solar field. Since 2007 the system was completely monitored to be able to analyse it. The work evaluates the performance of this kind of installation as well as the behaviour of the absorption chiller focusing on its steady state operation. This methodology was applied to the monitoring results of the installation in order to compare the first two years of operation of the system. It is concluded that the performance of the chiller showed better values in 2007 because the heat rejection temperature and the outdoor temperature were more favourable than in 2008. Nevertheless, the coefficient of performance achieved acceptable values in both periods, over 0.5, being the average chilling capacity between 3.6 kW and 5.8 kW.

11/02839 Subsidy programs on diffusion of solar water heaters: Taiwan's experience

Chang, K.-C. *et al. Energy Policy*, 2011, 39, (2), 563–567.

Financial incentives are essentially one of the key factors influencing diffusion of solar water heaters (SWHs) in many countries. Two subsidy programs were initiated by the government of Taiwan in 1986 (1986–1991) and 2000 (2000–present), respectively. Those long-term national programs are considered to be the driving force on local market expansion. In 2008, the regional subsidy programs for SWHs were announced by Kaohsiung city and Kiemen county, which resulted in the growth in sales. A revised subsidy was also initiated by the government of Taiwan in 2009. The subsidy is 50% more. However, the tremendous enlargement of market size with a high-level ratio of subsidy over total installation cost might result in a negative impact on a sustainable SWH industry and long-term development of the local market, which is associated with system design and post-installation service. This paper aims to address the relative efficiency and pitfalls of those national and regional programs.

11/02840 Thermal response of a series- and parallel-connected solar energy storage to multi-day charge sequences

Cruickshank, C. A. and Harrison, S. J. *Solar Energy*, 2011, 85, (1), 180–187.

The thermal response of a multi-tank thermal storage was studied under variable charge conditions. Tests were conducted on an experimental apparatus that simulated the thermal charging of the storage system by a solar collector over predetermined (prescribed) daylong periods. The storage was assembled from three standard 270 L hot-water storage tanks each charged through coupled, side-arm, natural convection heat exchangers which were connected in either a series- or parallel-flow configuration. Both energy storage rates and tank temperature profiles were experimentally measured during charge periods representative of two consecutive clear days or combinations of a clear and overcast day. During this time, no draw-offs were conducted. Of particular interest was the effect of rising and falling charge-loop temperatures and collector-loop flow rate on storage tank stratification levels. Results of this study show that the series-connected thermal storage reached high levels of temperature stratification in the storage tanks during periods of rising charge temperatures and also limited destratification during periods of falling charge temperature. This feature is a consequence of the series-connected configuration that allowed sequential stratification to occur in the component tanks and energy to be distributed according to temperature level. This effect was not observed in the parallel charge configuration. A further aspect of the study investigated the effect of increasing charge-loop flow rate on the temperature distribution within the series-connected storage and showed that, at high flow rates, the temperature distributions were found to be similar to those obtained during parallel charging. A disadvantage of both the high-flow series-connected and parallel-connected multi-tank storage is that falling charge-loop temperatures, which normally occur in the afternoon, tend to mix and destratify the storage tanks.

Wind energy

11/02841 A hybrid PSO–ANFIS approach for short-term wind power prediction in Portugal

Pousinho, H. M. I. *et al. Energy Conversion and Management*, 2011, 52, (1), 397–402.

The increased integration of wind power into the electric grid, as nowadays occurs in Portugal, poses new challenges due to its intermittency and volatility. Wind power prediction plays a key role in tackling these challenges. The contribution of this paper is to propose a new hybrid approach, combining particle swarm optimization and adaptive-network-based fuzzy inference system, for short-term wind power prediction in Portugal. Significant improvements regarding forecasting accuracy are attainable using the proposed approach, in comparison with the results obtained with five other approaches.

11/02842 A quantitative approach to wind farm diversification and reliability

Degeilh, Y. and Singh, C. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (2), 303–314.

This paper proposes a general planning method to minimize the variance of aggregated wind farm power output by optimally distributing a predetermined number of wind turbines over a preselected number of potential wind farming sites. The objective is to facilitate high wind power penetration through the search for steadier overall power output. Another optimization formulation that takes into account the correlations between wind power outputs and load is also presented. Three years of wind data from the recent NREL/3TIER study in the western USA provides the statistics for evaluating each site upon their mean power output, variance and correlation with each other so that the best allocations can be determined. The reliability study reported in this paper investigates the impact of wind power output variance reduction on a power system composed of a virtual wind power plant and a load modelled from the 1996 IEEE RTS. Some traditional reliability indices such as the LOLP are calculated and it is eventually shown that configurations featuring minimal global power output variances generally prove the most reliable provided the sites are not significantly correlated with the modelled load. Consequently, the choice of uncorrelated/negatively correlated sites is favoured.

11/02843 Assessing transient response of DFIG based wind turbines during voltage dips regarding main flux saturation and rotor deep-bar effect

Song, Z. *et al. Applied Energy*, 2010, 87, (10), 3283–3293.

With increasing wind power penetration, transient responses of doubly-fed-induction-generator (DFIG) based wind turbines gain attentive focus. Accurate prediction of transient performance of DFIG under grid faults is required with increasing wind power penetration. Taking into account the main flux saturation and deep-bar effect, this paper concentrates on transient responses and stability of the DFIG system under symmetrical grid faults. Their roles played in the enhancement of system transient stability are clarified. The analyses proposed contribute greatly to proper selection, design and coordination of protection devices and control strategies as well as stability studies.

11/02844 Assessment of wind energy potentiality at Kudat and Labuan, Malaysia using Weibull distribution function

Islam, M. R. *et al. Energy*, 2011, 36, (2), 985–992.

The wind resource is a crucial step in planning a wind energy project and detailed knowledge of the wind characteristic at a site is needed to estimate the performance of a wind energy project. In this paper, with the help of two-parameter Weibull distribution, the assessment of wind energy potentiality at Kudat and Labuan in 2006–2008 was carried out. WRPLOT software has been used to show the wind direction and resultant of the wind speed direction. The monthly and yearly highest mean wind speeds were 4.76 m/s at Kudat and 3.39 m/s at Labuan respectively. The annual highest values of the Weibull shape parameter (k) and scale parameter (c) were 1.86 and 3.81 m/s, respectively. The maximum wind power density was found to be 67.40 W/m^2 at Kudat for 2008. The maximum wind energy density was found to be 590.40 kWh/m^2/year at Kudat in 2008. The highest most probable wind speed and wind speed carrying maximum energy were estimated 2.44 m/s at Labuan in 2007 and 6.02 m/s at Kudat in 2007. The maximum deviation, at wind speed more than 2 m/s, between observed and Weibull frequency distribution was about 5%. The most probable wind directions (blowing from) were 190° and 269° at Kudat and Labuan through the study years. From this study, it is concluded that these sites are unsuitable for the large-scale wind energy generation. However, small-scale wind energy can be generated at the turbine height of 100 m.

11/02845 Design of intelligent controllers for wind generation system with sensorless maximum wind energy control

Lin, W.-M. *et al. Energy Conversion and Management*, 2011, 52, (2), 1086–1096.

This paper presents the design of an on-line training recurrent fuzzy neural network (RFNN) controller with a high-performance model reference adaptive system (MRAS) observer for the sensorless control of a induction generator (IG). The modified particle swarm optimization (MPSO) is adopted in this study to adapt the learning rates in the back-propagation process of the RFNN to improve the learning capability. By using the proposed RFNN controller with MPSO, the IG system can work for stand-alone power application effectively. The proposed output maximization control is achieved without mechanical sensors such as the wind speed or position sensor, and the new control system will deliver maximum electric power with light weight, high efficiency, and high reliability. The estimation of the rotor speed is based on the MRAS control theory. A sensorless vector-control strategy for an IG operating in a grid-connected variable speed wind energy conversion system can be achieved.

11/02846 Efficiency assessment of a wind pumping system

Lara, D. D. *et al. Energy Conversion and Management*, 2011, 52, (2), 795–803.

The combined efficiency of the components determines overall system performance in electric wind pumping systems. The authors evaluated a system composed of a 3 kW wind generator feeding a battery bank of 48 V/880 Ah by means of a non-controlled six-pulse rectifier. Connected to this battery bank was a 1.5 kW inverter that generated 220 V at 50 Hz, which powers a 1.1 kW single-phase electric pump. At the University of Concepcion, Chile, energy losses in each electrical component was determined using a data collection system configured to measure electrical variables in real time. The electrical power generated by the wind generator for different wind speeds averaged 38% lower than the power curve provided by the manufacturer. Electromechanical tests performed in a lab showed the operation efficiency of the electric generator of the wind turbine averaged 80%. This information, along with the electrical power output, and the wind velocity measured during field operation allowed us to determine the rotor's power coefficient C_p, which had a maximum value of 35%. For the stored energy components measured data indicated that the rectifier, the battery bank, and the inverter operated with average efficiencies of 95%, 78% and 86%, respectively. The combined component efficiencies showed a maximum of 17% of the wind energy would be available for water pumping. Since a large amount of wind energy was dissipated during the energy conversion process, new configurations should be analysed that could avoid such losses in wind pumping systems.

11/02847 Gone with the wind? – electricity market prices and incentives to invest in thermal power plants under increasing wind energy supply

Traber, T. and Kemfert, C. *Energy Economics*, 2011, 33, (2), 249–256.

The increased wind energy supplied to many electricity markets around the world has to be balanced by reliably ramping units or other complementary measures when wind conditions are low. At the same time wind energy impacts both, the utilization of thermal power plants and the market prices. While the market prices tend to decrease, the impact on the utilization of different plant types is at the outset unclear. To analyse the incentives to invest in thermal power plants under increased wind energy supply, the authors develop a computational model which includes ramping restrictions and costs and apply it to the German case. It is found that due to current wind supply the market prices are reduced by more than five percent, and the incentives to invest in natural gas fired units are largely reduced. An increased wind supply erodes their attractiveness further. Consequently, a gap between the need for and the incentive to provide flexibility can be expected.

11/02848 Loss evaluation and design optimisation for direct driven permanent magnet synchronous generators for wind power

Eriksson, S. and Bernhoff, H. *Applied Energy*, 2011, 88, (1), 265–271.

When designing a generator for a wind turbine it is important to adapt the generator to the source, i.e. the wind conditions at the specific site. Furthermore, the variable speed operation of the generator needs to be considered. In this paper, electromagnetic losses in direct driven permanent magnet synchronous generators are evaluated through simulations. Six different generators are compared to each other. The simulations are performed by using an electromagnetic model, solved in a finite element environment and a control model developed in MATLAB. It is shown that when designing a generator it is important to consider the statistical wind distribution, control system, and aerodynamic efficiency in order to evaluate the performance properly. In this paper, generators with high overload capability are studied since they are of interest for this specific application. It is shown that a generator optimized for a minimum of losses will have a high overload capability.

11/02849 Maximum generation power evaluation of variable frequency offshore wind farms when connected to a single power converter

Gomis-Bellmunt, O. *et al. Applied Energy*, 2010, 87, (10), 3103–3109.

The paper deals with the evaluation of power generated by variable and constant frequency offshore wind farms connected to a single large power converter. A methodology to analyse different wind speed scenarios and system electrical frequencies is presented and applied to a case study, where it is shown that he variable frequency wind farm concept (VF) with a single power converter obtains 92% of the total available power, obtained with individual power converters in each wind turbine (PC). The PC scheme needs multiple power converters implying drawbacks in terms of cost, maintenance and reliability. The VF scheme is also compared to a constant frequency scheme CF, and it is shown that a significant power increase of more than 20% can be obtained with VF. The case study considers a wind farm composed of four wind turbines based on synchronous generators.

11/02850 Modelling and simulation of a high penetration wind diesel system with battery energy storage

Sebastian, R. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 767–774.

Wind diesel hybrid systems (WDHS) are isolated power systems which combine diesel generators (DG) with wind turbine generators (WTG). Depending on the generators which are supplying, high penetration (HP) WDHS have three operation modes: diesel only (DO), wind diesel (WD) and wind only (WO). The HP-WDHS presented in this article consists of a diesel engine (DE), a synchronous machine (SM), a wind turbine generator, the consumer load, a Ni-Cd battery-based energy storage system (BESS) and a dump load. The DE can be engaged (DO and WD modes) or disengaged (WO mode) from the SM by means of a clutch. All the models of the previously mentioned components are presented and the performance of the WDHS has been tested through dynamic simulation. Simulation results with graphs for the frequency and voltage of the isolated power system, active powers generated/absorbed by the different elements and the battery voltage/current/state of charge are presented for a load change in WO mode and for the transition from WO to WD mode in order to substitute a supplying BESS for the DE as the active power source.

11/02851 Operation and control of a grid-connected DFIG-based wind turbine with series grid-side converter during network unbalance

Liao, Y. *et al. Electric Power Systems Research*, 2011, 81, (1), 228–236.

This paper proposes a control scheme of a grid-connected doubly-fed induction generator (DFIG) wind turbine with series grid-side converter (SGSC) to improve the control and operation performance of DFIG system during network unbalance. The behaviours of DFIG system with SGSC under unbalanced grid voltage conditions are described. The SGSC is controlled to inject voltage in series to balance the stator voltage. Therefore, the adverse effects of voltage unbalance upon the DFIG such as large stator and rotor current unbalances, electromagnetic torque and power pulsations are removed and the conventional vector control strategy for the rotor-side converter (RSC) remains in full force under unbalanced conditions. Meanwhile, three selective control targets for the parallel grid-side converter (PGSC), such as eliminating the oscillations in total active or reactive power, or no negative-sequence current injected to the grid are identified and compared. Besides, the proportional resonant controllers in the stationary reference frame are designed for both the SGSC and PGSC to further improve the dynamic performance of the whole system. Finally, the ratings and losses of the SGSC and the injected transformer are discussed and the effectiveness of the proposed control scheme is verified by the simulation results of a 2 MW DFIG-based wind turbine with SGSC under steady state and small transient grid voltage unbalance.

11/02852 Optimal wind-hydro solution for the Marmara region of Turkey to meet electricity demand

Dursun, B. *et al. Energy*, 2011, 36, (2), 864–872.

Wind power technology is now a reliable electricity production system. It presents an economically attractive solution for the continuously increasing energy demand of the Marmara region located in Turkey. However, the stochastic behaviour of wind speed in the Marmara region can lead to significant disharmony between wind energy production and electricity demand. Therefore, to overcome wind's variable nature, a more reliable solution would be to integrate hydropower with wind energy. In this study, a methodology to estimate an optimal wind-hydro solution is developed and it is subsequently applied to six typical different site cases in the Marmara region in order to define the most beneficial configuration of the wind-hydro system. All numerical calculations are based on the long-term wind speed measurements, electrical load demand and operational characteristics of the system components.

11/02853 Performance comparison of six numerical methods in estimating Weibull parameters for wind energy application

Tian, P. C. *et al. Applied Energy*, 2011, 88, (1), 272–282.

Two-parameter Weibull function has been widely applied to evaluate wind energy potential. In this paper, six kinds of numerical methods commonly used for estimating Weibull parameters are reviewed; i.e. the moment, empirical, graphical, maximum likelihood, modified maximum likelihood and energy pattern factor method. Their performance is compared through Monte Carlo simulation and analysis of actual wind speed according to the criterions such as Kolmogorov–Smirnov test, parameter error, root mean square error, and wind energy error. The results show that, in simulation test of random variables, the graphical method's performance in estimating Weibull parameters is the worst one, followed by the empirical and energy pattern factor methods, if data number is smaller. The performance for all the six methods is improved while data number becomes larger; the graphical method is even better than the empirical and energy pattern factor methods. The maximum likelihood, modified maximum likelihood and moment methods present relatively more excellent ability throughout the simulation tests. From analysis of actual data, it is found that if wind speed distribution matches well with Weibull function, the six methods are applicable; but if not, the maximum likelihood method performs best followed by the modified maximum likelihood and moment methods, based on double checks including potential energy and cumulative distribution function.

11/02854 Performance of a grid-connected wind generation system with a robust susceptance controller

Rahim, A. H. M. A. and Nowicki, E. P. *Electric Power Systems Research*, 2011, 81, (1), 149–157.

Wind turbine-driven induction generators are vulnerable to transient disturbances like wind gusts and low voltages on the system. The fixed capacitor at the generator terminal or the limited support from the grid may not be able to provide the requisite reactive power under these abnormal conditions. This paper presents a susceptance control strategy for a variable speed wound-rotor induction generator which can cater for the reactive power requirement. The susceptance is adjusted through a robust feedback controller included in the terminal voltage driven automatic excitation control circuit. The fixed parameter robust controller design is carried out in frequency domain using multiplicative uncertainty modelling and $H\infty$ norms. The robustness of the controller has been evaluated through optimally tuned PID controllers. Simulation results show that the robust controller can effectively restore normal operation following emergencies like sudden load changes, wind gusts and low voltage conditions. The proposed robust controller has been shown to have adequate fault ride through capabilities in order to be able to meet connection requirements defined by transmission system operators.

11/02855 Probability distributions for offshore wind speeds

Morgan, E. C. *et al. Energy Conversion and Management*, 2011, 52, (1), 15–26.

In planning offshore wind farms, short-term wind speeds play a central role in estimating various engineering parameters, such as power output, extreme wind load, and fatigue load. Lacking wind speed time series of sufficient length, the probability distribution of wind speed serves as the primary substitute for data when estimating design parameters. It is common practice to model short-term wind speeds with the Weibull distribution. Using 10-min wind speed time series at 178 ocean buoy stations ranging from 1 month to 20 years in duration, the authors show that the widely-accepted Weibull distribution provides a poor fit to the distribution of wind speeds when compared with more complicated models. The authors compare distributions in terms of three different metrics: probability plot R^2, estimates of average turbine power output, and estimates of extreme wind speed. While the Weibull model generally gives larger R^2 than any other two-parameter distribution, the bimodal Weibull, Kappa, and Wakeby models all show R^2 values significantly closer to 1 than the other distributions considered (including the Weibull), with the bimodal Weibull giving the best fits. The Kappa and Wakeby distributions fit the upper tail (higher wind speeds) of a sample better than the bimodal Weibull, but may drastically over-estimate the frequency of lower wind speeds. Because the average turbine power is controlled by high wind speeds, the Kappa and Wakeby estimate average turbine power output very well, with the Kappa giving the least bias and mean square error out of all the distributions. The two-parameter Lognormal distribution performs best for estimating extreme wind speeds, but still gives estimates with significant error. The fact that different distributions excel under different applications motivates further research on model selection based upon the engineering parameter of interest.

11/02856 Profiling the regional wind power fluctuation in China

Yu, D. *et al. Energy Policy*, 2011, 39, (1), 299–306.

As China starts to build six 10-GW wind zones in five provinces by 2020, accommodating the wind electricity generated from these large wind zones will be a great challenge for the regional grids. Inadequate wind observing data hinders profiling the wind power fluctuations at the regional grid level. This paper proposed a method to assess the seasonal and diurnal wind power patterns based on the wind speed data from the NASA GEOS-5 DAS system, which provides data to the study of climate processes including the long-term estimates of meteorological quantities. The wind power fluctuations for the six largest wind zones in China are presented with both the capacity factor and the megawatt wind power output. The measured hourly wind output in a regional grid is compared to the calculating result to test the analysing model. To investigate the offsetting effect of dispersed wind farms over large regions, the regional correlations of hourly wind power fluctuations are calculated. The result illustrates the different offsetting effects of minute and hourly fluctuations.

11/02857 Public–private partnerships for wind power generation: the Portuguese case

Martins, A. C. *et al. Energy Policy*, 2011, 39, (1), 94–104.

Today's portfolio of energy production, based mostly on fossil fuels, and increasing energy consumption go against a sustainable vision for the world's development. Governments are shifting their energy policies towards renewable, non-pollutant sources of energy, developing large investment plans to ensure an adequate response to energy demand growth while keeping the environmental impact within reasonable boundaries. As in many other infrastructure-related sectors, new models for the provision of these facilities, and services, are being developed. Over the past 20 years, highways, hospitals, social housing, airports and dams have been developed in close collaboration with the private sector, not only in a contractor–supplier relation but also in deeper partnerships where the private sector assumes a substantial responsibility in managing and running the business. These models are known as public–private partnerships (PPPs). This research will look at the Portuguese experience in the application of PPP arrangements in the energy sector, particularly as far as the development of wind power plants is concerned. The evaluation procedures for selecting the private partner, the contract structure and the risk-sharing agreement are some of the issues deserving special attention.

11/02858 Security-constrained expansion planning of fast-response units for wind integration

Kamalinia, S. *et al. Electric Power Systems Research*, 2011, 81, (1), 107–116.

This paper proposes a stochastic expansion planning of fast-response thermal units for the large-scale integration of wind generation (WG). The paper assumes that the WG integration level is given and considers the short-term thermal constraints and the volatility of wind units in the planning of fast-response thermal units. The new fast-response units are proposed by market participants. The security-constrained expansion planning approach will be used by an ISO or a regulatory body to secure the optimal planning of the participants' proposed fast-response units with the WG integration. Random outages of generating units and transmission lines as well as hourly load and wind speed forecast errors are modelled in Monte Carlo scenarios. The Monte Carlo simplification methods are introduced to handle large-scale stochastic expansion planning as a tradeoff between the solution accuracy and the calculation time. The effectiveness of the proposed approach is demonstrated through numerical simulations.

11/02859 Synthesis on PI-based pitch controller of large wind turbines generator

Wang, J. *et al. Energy Conversion and Management*, 2011, 52, (2), 1288–1294.

In this paper, proportional and integral (PI) pitch controller is analysed and designed for a large wind turbine generator (WTG) by using graphical approach. First, the transfer function of the wind turbine which including a time delay in the hydraulic pressure driven unit of pitch control system is derived. The complete stabilizing set in the plain of proportional–integral gains can then be drawn and identified immediately based on the presented method, rather than computed mathematically. The influence of the time delay in hydraulic pressure driven of pitch unit on the stability region of PI controller is analysed as well. Finally, the proposed techniques are verified by using simulation results to the actual model of WTG.

11/02860 The economics of offshore wind

Green, G. and Vasilakos, N. *Energy Policy*, 2011, 39, (2), 496–502.

This paper presents an overview of the main issues associated with the economics of offshore wind systems. Investment in offshore wind systems has been growing rapidly throughout Europe, and the technology will be essential in meeting EU targets for renewable energy in 2020. Offshore wind suffers from high installation and connection costs, however, making government support essential. The authors review various support policies used in Europe, concluding that tender-based feed-in tariff schemes, as used in Denmark, may be best for providing adequate support while minimizing developers' rents. It may prove economic to build an international offshore grid connecting wind farms belonging to different countries that are sited close to each other.

Others, including economics

11/02861 A case study of energy use and economical analysis of irrigated and dryland wheat production systems

Ghorbani, R. *et al. Applied Energy*, 2011, 88, (1), 283–288.

Current conventional agricultural systems using intensive energy has to be re-vitalized by new integrated approaches relying on renewable energy resources, which can allow farmers to stop depending on fossil resources. The aim of the present study was to compare wheat production in dry-land (low input) and irrigated (high input) systems in terms of energy ratio, energy efficiency, benefit/cost ratio and amount of renewable energy use. Data were collected from 50 irrigated and 50 dry-land wheat growers by using a face-to-face questionnaire in 2009. The results showed that the total energy requirement under low input was 9354.2 MJ ha^{-1}, whereas under high input systems it was 45,367.6 MJ ha^{-1}. Total energy input consumed in both dry-land and irrigated systems could be classified as direct, indirect, renewable and non-renewable energies which average in two wheat production systems were 47%, 53%, 24% and 76%, respectively. Energy ratios of 3.38 in dry-land and 1.44 in irrigated systems were achieved. The benefit–cost ratios were 2.56 in dry-land and 1.97 in irrigated wheat production systems. Based on the results of the present study, dry-land farming can have a significant positive effect on energy-related factors especially in dry and semi-dry climates such as Iran.

11/02862 A global renewable energy system: a modelling exercise in ETSAP/TIAM

Føyn, T. H. Y. *et al. Applied Energy*, 2011, 88, (2), 526–534.

This paper aims to test the ETSAP^2-TIAM global energy system model and to try out how far it can go towards a global 100% renewable energy system with the existing model database. This will show where limits in global resources are met and where limits in the data fed to the model until now are met. Results from the modelling are global and regional energy consumption, emission of greenhouse gasses and thereby potential increase in global mean temperature. Furthermore, total system costs are compared to a reference scenario. Existing analysis with TIAM shows different ways of reaching the 2 °C target (increase in global mean temperature) and also how uncertainty on different factors influences the optimal solution. The main conclusion from existing analysis with TIAM is that the 2 °C target is possible to reach, but it will be expensive. Another very important point is that if uncertainty on the value of the climate sensitivity (C_s) is taken into account then the optimal strategy calls for early action compared to a full foresight optimization using the most probable value of C_s.

11/02863 A hybrid model for the optimum integration of renewable technologies in power generation systems

Poullikkas, A. *et al. Energy Policy*, 2011, 39, (2), 926–935.

The main purpose of this work is to assess the unavoidable increase in the cost of electricity of a generation system by the integration of the necessary renewable energy sources for power generation (RES-E) technologies in order for the EU member states to achieve their national RES energy target. The optimization model developed uses a genetic algorithm (GA) technique for the calculation of both the additional cost of electricity due to the penetration of RES-E technologies as well as the required RES-E levy in the electricity bills in order to fund this RES-E penetration. Also, the procedure enables the estimation of the optimum feed-in-tariff to be offered to future RES-E systems. Also, the overall cost increase in the electricity sector for the promotion of RES-E technologies, for the period 2010–2020, is analysed taking into account factors, such as, the fuel avoidance cost, the carbon dioxide emissions avoidance cost, the conventional power system increased operation cost, etc. The overall results indicate that in the case of RES-E investments with internal rate of return (IRR) of 10% the cost of integration is higher, compared to RES-E investments with no profit, (i.e. IRR at 0%) by 0.3–0.5 €c/kWh (in real prices), depending on the RES-E penetration level.

11/02864 A review of vibration-based MEMS piezoelectric energy harvesters

Saadon, S. and Sidek, O. *Energy Conversion and Management*, 2011, 52, (1), 500–504.

The simplicity associated with the piezoelectric micro-generators makes it very attractive for MEMS applications, especially for remote systems. In this paper the authors reviewed the work carried out by researchers during the past 3 years. The improvements in experimental results obtained in the vibration-based MEMS piezoelectric energy harvesters show very good scope for MEMS piezoelectric harvesters in the field of power MEMS in the near future.

11/02865 Analysis of dynamic effects relevant for the wear damage in hydraulic machines for wave energy conversion

Yang, L. *et al. Ocean Engineering*, 2010, 37, (13), 1089–1102.

The present paper deals with a mathematical model of a heaving-buoy wave energy converter (WEC) equipped with high-pressure hydraulic power take-off machinery for energy conversion. This model is based on linear hydrodynamic theory, and a hybrid frequency–time domain model is used to study the dynamics of the heaving-body exposed to an irregular incident wave. For the power take-off system, end-stop devices are provided to protect the hydraulic machinery when the buoy is exposed to severe sea states. The model also takes into account the lubricated friction force and pressure drops of orifice flow through the valves in the hydraulic system. All the forces mentioned in the hydraulic power take-off machinery have non-linear features. A complete non-linear state space model for the WEC system is presented in this study. The WEC system was numerically simulated for different cylinder lengths under a fixed volume. The effect of fluid compressibility in the cylinder has been investigated in the mathematical model. High frequency oscillations (HFOs) caused by the compressibility of the fluid are displayed in the time series and in corresponding power spectra, and variation is shown for different cylinder sizes. Piston ring and cylinder bore wear damage is estimated by using Archard's equation on the basis of the simulation results. A comparison of these results with a performance of an identical WEC system which neglects fluid compressibility has been done in this work. It shows that although the spectral power is small, HFO can make a large contribution to both the ring and cylinder bore wear. For the purpose of wear prediction, oscillations at or below the wave frequency and HFO may be equally important.

11/02866 Capacity choice and water management in hydroelectricity systems

Haddad, M. S. *Energy Economics*, 2011, 33, (2), 168–177.

This paper proposes a simple two-period model that captures the seasonal pattern of water inflows and electricity demand observed in many countries where hydropower is a major source of electricity supply. The model characterizes the effects of different inflows pattern on the optimal water management, capacity, and the associated electricity production and price. The first best capacity is a non-monotonic function of water inflows, which provides a rationale for the observed differences in reservoirs sizes across hydropower systems around the world. The monopoly solution is qualitatively similar to the first best outcome, and the privatization of hydroelectric power generation systems does not always imply a social welfare loss.

11/02867 Converting *Eucalyptus* biomass into ethanol: financial and sensitivity analysis in a co-current dilute acid process. Part II

Gonzalez, R. *et al. Biomass and Bioenergy*, 2011, 35, (2), 767–772.

The technical and financial performance of high yield *Eucalyptus* biomass in a co-current dilute acid pretreatment followed by enzymatic hydrolysis process was simulated using WinGEMS® and Excel®. Average ethanol yield per dry Mg of *Eucalyptus* biomass was approximately 347.6 L of ethanol (with average carbohydrate content in the biomass around 66.1%) at a cost of \$0.49 L^{-1} of ethanol, cash cost of ~\$0.46 L^{-1} and CAPEX of \$1.03 L^{-1} of ethanol. The main cost drivers are: biomass, enzyme, tax, fuel (gasoline), depreciation and labor. Profitability of the process is very sensitive to biomass cost, carbohydrate content (%) in biomass and enzyme cost. Biomass delivered cost was simulated and financially evaluated in Part I. In Part II the conversion of this raw material into cellulosic ethanol using the dilute acid process is evaluated.

11/02868 Developing sustainable residential buildings in Saudi Arabia: a case study

Taleb, H. M. and Sharples, S. *Applied Energy*, 2011, 88, (1), 383–391.
This paper assesses the energy and water consumption practices of existing housing in Saudi Arabia, with the ultimate aim of establishing guidelines for delivering sustainable residential buildings in the near future. In order to achieve this aim the current status of a typical Saudi residence (i.e. an apartment complex) is investigated in terms of energy and water consumption using simulation software packages. The paper then examines the prospects for applying various measures to the typical Saudi residence to manage energy and water use more sustainably. This research identifies several design-related faults common to Saudi Arabian house design. These faults contribute to an inefficient use of energy and domestic water resources. Finally, the paper puts forward a set of recommendations and guidelines, design-related and otherwise, to enhance the sustainability of future Saudi residential buildings.

11/02869 Energy metrics of photovoltaic/thermal and earth air heat exchanger integrated greenhouse for different climatic conditions of India

Nayak, S. and Tiwari, G. N. *Applied Energy*, 2010, 87, (10), 2984–2993.
This study evaluates the annual thermal and exergy performance of a photovoltaic/thermal (PV/T) and earth air heat exchanger (EAHE) system, integrated with a greenhouse, located at IIT Delhi, India, for different climatic conditions of Srinagar, Mumbai, Jodhpur, New Delhi and Bangalore. Various energy metrics are compared, such as energy payback time (EPBT), electricity production factor (EPF) and life cycle conversion efficiency (LCCE) of the system by considering four weather conditions (a–d type) for five climatic zones. The embodied energy and annual energy outputs have been used for evaluation of the energy metrics. The annual overall thermal energy, annual electrical energy savings and annual exergy were found to be best for the climatic condition of Jodhpur at 29,156.8 kWh, 1185 kWh and 1366.4 kWh, respectively when compared with other weather stations covered in the study, due to higher solar intensity *I* and sunshine hours, and lowest for Srinagar station. The results also showed that energy payback time for Jodhpur station is lowest at 16.7 years and highest for Srinagar station at 21.6 years. Electricity production factor (EPF) is highest for Jodhpur, i.e. 2.04 and life cycle conversion efficiency (LCCE) is highest for Srinagar station. It is also observed that LCCE increases with increase in life cycle.

11/02870 Enhancing local distinctiveness fosters public acceptance of tidal energy: a UK case study

Devine-Wright, P. *Energy Policy*, 2011, 39, (1), 83–93.
Tidal energy has the technical potential to form part of a low carbon electricity sector, however, its ‘social potential’ is less clear, as few empirical studies of public beliefs and responses have been conducted to date. This research addressed this gap by investigating a tidal energy converter in Northern Ireland, said to be the first grid-connected device of its kind in the world. Data was collected from 313 residents of two nearby villages using mixed methods, guided by a conceptual framework that avoided ‘NIMBY’ assumptions and instead drew on place theory. Findings indicated strong support for the project, arising from beliefs that the project enhanced local distinctiveness by ‘putting the area on the map worldwide’; appeared visually familiar and helped tackle climate change. These positive beliefs outweighed concerns about outcome and process aspects, which were preponderant in one of the two villages. The project was interpreted to have few positive local economic outcomes, to potentially threaten local livelihoods and local ecology. Moreover, residents expressed cynicism about consultation procedures, and reported low levels of behavioural engagement. Implications of the findings for the literature on public acceptance of renewable energy, and for the emerging marine energy sector specifically, are discussed.

11/02871 Exploring the potential of *Eucalyptus* for energy production in the Southern United States: financial analysis of delivered biomass. Part I

Gonzalez, R. *et al. Biomass and Bioenergy*, 2011, 35, (2), 755–766.
Eucalyptus plantations in the southern USA offer a viable feedstock for renewable bioenergy. Delivered cost of eucalypt biomass to a bioenergy facility was simulated in order to understand how key variables affect biomass delivered cost. Three production rates (16.8, 22.4 and 28.0 $Mg\,ha^{-1}\,y^{-1}$, dry weight basis) in two investment scenarios were compared in terms of financial analysis, to evaluate the effect of productivity and land investment on the financial indicators of the project. Delivered cost of biomass was simulated to range from \$55.1 to \$66.1 per delivered Mg (with freight distance of 48.3 km from plantation to biorefinery) depending on site productivity (without considering land investment) at 6% IRR. When land investment was included in the analysis, delivered biomass cost increased to range from \$65.0 to \$79.4 per delivered Mg depending on site productivity at 6% IRR. Conversion into cellulosic ethanol might be promising with biomass delivered cost lower than \$66 Mg^{-1}. These delivered costs and investment analysis show that *Eucalyptus* plantations are a potential biomass source for bioenergy production for the southern USA.

11/02872 Fuzzy rule-based model for hydropower reservoirs operation

Moeini, R. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (2), 171–178.
Real-time hydropower reservoir operation is a continuous decision-making process of determining the water level of a reservoir or the volume of water released from it. The hydropower operation is usually based on operating policies and rules defined and decided upon in strategic planning. This paper presents a fuzzy rule-based model for the operation of hydropower reservoirs. The proposed fuzzy rule-based model presents a set of suitable operating rules for release from the reservoir based on ideal or target storage levels. The model operates on an ‘if-then’ principle, in which the ‘if’ is a vector of fuzzy premises and the ‘then’ is a vector of fuzzy consequences. In this paper, reservoir storage, inflow, and period are used as premises and the release as the consequence. The steps involved in the development of the model include, construction of membership functions for the inflow, storage and the release, formulation of fuzzy rules, implication, aggregation and defuzzification. The required knowledge bases for the formulation of the fuzzy rules is obtained form a stochastic dynamic programming (SDP) model with a steady state policy. The proposed model is applied to the hydropower operation of the Dez reservoir in Iran and the results are presented and compared with those of the SDP model. The results indicate the ability of the method to solve hydropower reservoir operation problems.

11/02873 Green power voluntary purchases: price elasticity and policy analysis

Mewton, R. T. and Cacho, O. J. *Energy Policy*, 2011, 39, (1), 377–385.
Green power schemes offer electricity from renewable energy sources to customers for a higher price than ordinary electricity. This study examines the demand characteristics of green power in Australia and policies which could increase its sales. A sample of 250 pooled time series and cross-sectional observations was used to estimate a statistically significant elasticity of demand for green power with respect to price of −0.96 with a 95% confidence interval of ±68%. The wide variation in market penetration between jurisdictions and between countries for green power, and the low awareness of green power found by surveys indicate that green power sales could be increased by appropriate marketing and government policies. The most cost-effective means to increase sales was found to be advertising campaigns although only one Australian example was found, in the state of Victoria in 2005. It was also found that full tax deductibility of the green power premium to residential customers, exemption from the goods and services tax and a tax rebate for green power are all probably less cost effective for promoting sales than direct government purchase of green power, in terms of cost per unit of increased sales.

11/02874 Growth and renewable energy in Europe: a random effect model with evidence for neutrality hypothesis

Menegaki, A. N. *Energy Economics*, 2011, 33, (2), 257–263.
This is an empirical study on the causal relationship between economic growth and renewable energy for 27 European countries in a multivariate panel framework over the period 1997–2007 using a random effect model and including final energy consumption, greenhouse gas emissions and employment as additional independent variables in the model. Empirical results do not confirm causality between renewable energy consumption and gross domestic product, although panel causality tests unfold short-run relationships between renewable energy and greenhouse gas emissions and employment. The estimated cointegration factor refrains from unity, indicating only a weak, if any, relationship between economic growth and renewable energy consumption in Europe, suggesting evidence of the neutrality hypothesis, which can partly be explained by the uneven and insufficient exploitation of renewable energy sources across Europe.

11/02875 Levelised costs of wave and tidal energy in the UK: cost competitiveness and the importance of ‘banded’ renewables obligation certificates

Allan, G. *et al. Energy Policy*, 2011, 39, (1), 23–39.

In this paper, publicly available cost data are used to calculate the private levelized costs of two marine energy technologies for UK electricity generation: wave and tidal stream power. These estimates are compared to those for 10 other electricity generation technologies whose costs were identified by the British government. Under plausible assumptions for costs and performance, point estimates of the levelized costs of wave and tidal stream generation are £190 and £81/MWh, respectively. Sensitivity analysis shows how these relative private levelized costs calculations are affected by variation in key parameters, specifically the assumed capital costs, fuel costs and the discount rate. The authors also consider the impact of the introduction of technology-differentiated financial support for renewable energy on the cost competitiveness of wave and tidal stream power. Further, the authors compare the impact of the current British government support level to the more generous degree of assistance for marine technologies that is proposed by the Scottish government.

11/02876 Opportunity for profitable investments in cellulosic biofuels

Babcock, B. A. *et al. Energy Policy*, 2011, 39, (2), 714–719.

Research efforts to allow large-scale conversion of cellulose into biofuels are being undertaken in the US and EU. These efforts are designed to increase logistic and conversion efficiencies, enhancing the economic competitiveness of cellulosic biofuels. However, not enough attention has been paid to the future market conditions for cellulosic biofuels, which will determine whether the necessary private investment will be available to allow a cellulosic biofuels industry to emerge. The authors examine the future market for cellulosic biofuels, differentiating between cellulosic ethanol and ‘drop-in’ cellulosic biofuels that can be transported with petroleum fuels and have equivalent energy values. It was found that emergence of a cellulosic ethanol industry is unlikely without costly government subsidies, in part because of strong competition from conventional ethanol and limits on ethanol blending. If production costs of drop-in cellulosic biofuels fall enough to become competitive, then their expansion will not necessarily cause feedstock prices to rise. As long as local supplies of feedstocks that have no or low-valued alternative uses exist, then expansion will not cause prices to rise significantly. If cellulosic feedstocks come from dedicated biomass crops, then the supply curves will have a steeper slope because of competition for land.

11/02877 Optimal sizing study of hybrid wind/PV/diesel power generation unit

Belfkira, R. *et al. Solar Energy*, 2011, 85, (1), 100–110.

In this paper, a methodology of sizing optimization of a stand-alone hybrid wind/PV/diesel energy system is presented. This approach makes use of a deterministic algorithm to suggest, among a list of commercially available system devices, the optimal number and type of units ensuring that the total cost of the system is minimized while guaranteeing the availability of the energy. The collection of 6 months of data of wind speed, solar radiation and ambient temperature recorded for every hour of the day were used. The mathematical modelling of the main elements of the hybrid wind/PV/diesel system is exposed showing the more relevant sizing variables. A deterministic algorithm is used to minimize the total cost of the system while guaranteeing the satisfaction of the load demand. A comparison between the total cost of the hybrid wind/PV/diesel energy system with batteries and the hybrid wind/PV/diesel energy system without batteries is presented.

11/02878 Potential of renewable energy systems in China

Liu, W. *et al. Applied Energy*, 2011, 88, (2), 518–525.

Along with high-speed economic development and increasing energy consumption, the Chinese Government faces a growing pressure to maintain the balance between energy supply and demand. In 2009, China has become both the largest energy consumer and CO_2 emitting country in the world. In this case, the inappropriate energy consumption structure should be changed. As an alternative, a suitable infrastructure for the implementation of renewable energy may serve as a long-term sustainable solution. The perspective of a 100% renewable energy system has been analysed and discussed in some countries previously. In this process, assessment of domestic renewable energy sources is the first step. Then appropriate methodologies are needed to perform energy system analyses involving the integration of more sustainable strategies. Denmark may serve as an example of how sustainable strategies can be implemented. The Danish system has demonstrated the possibility of converting into a 100% renewable energy system. This paper discusses the perspective of renewable energy in China firstly, and then analyses whether it is suitable to adopt similar methodologies applied in other countries as China approaches a renewable energy system. The conclusion is that China’s domestic renewable energy sources are abundant and show the possibility to cover future energy demand; the methodologies used to analyse a 100% renewable energy system are applicable in China. Therefore, proposing an analysis of a 100% renewable energy system in China is not unreasonable.

11/02879 Providing all global energy with wind, water, and solar power, Part I: technologies, energy resources, quantities and areas of infrastructure, and materials

Jacobson, M. Z. and Delucchi, M. A. *Energy Policy*, 2011, 39, (3), 1154–1169.

This study analyses the feasibility of providing worldwide energy for all purposes (electric power, transportation, heating/cooling, etc.) from wind, water, and sunlight (WWS). Part I discusses WWS energy system characteristics, current and future energy demand, availability of WWS resources, numbers of WWS devices, and area and material requirements. Part II addresses variability, economics, and policy of WWS energy. The authors estimate that 3,800,000 5-MW wind turbines, 49,000 300-MW concentrated solar plants, 40,000 300-MW solar PV power plants, 1.7 billion 3-kW rooftop PV systems, 5350 100-MW geothermal power plants, 270 new 1300-MW hydroelectric power plants, 720,000 0.75-MW wave devices, and 490,000 1-MW tidal turbines can power a 2030 WWS world that uses electricity and electrolytic hydrogen for all purposes. Such a WWS infrastructure reduces world power demand by 30% and requires only about 0.41% and about 0.59% more of the world’s land for footprint and spacing, respectively. The authors suggest producing all new energy with WWS by 2030 and replacing the pre-existing energy by 2050. Barriers to the plan are primarily social and political, not technological or economic. The energy cost in a WWS world should be similar to that today.

11/02880 Regional renewable energy and resource planning

Lam, H. L. *et al. Applied Energy*, 2011, 88, (2), 545–550.

The exploitation of the energy potential in biomass in a specific geographical region is frequently constrained by high production costs and the amount of land required per unit of energy generated. In addition, the distributed nature of the biomass resource and its normally low energy density may result in large transportation costs. Biomass also requires large land areas to collect and process the incoming solar radiation before the energy can be harvested. Previously published works on regional energy clustering (REC) and the regional resources management composite curve (RMC), have been extended in this paper to tackle simultaneously the issues of the biomass supply chain, transportation, and land use. The RMC is a tool for supporting decision-making in regional resource management. It provides a complete view of energy and land availability in a region, displaying their trade-offs in a single plot. The extension presented in this work has been developed in two steps. The first step presents the regional energy cascade analysis, which estimates the energy target within regional supply chains and provides the result for energy exchange flows between zones, the quantity of energy required to be imported/exported, and the locations of the demands. In the second step, the initial results are analysed against potential measures for improving the energy and land use targets by using the RMC and a set of rules for its manipulation. The presented method provides the option to assess the priorities: either to produce and sell the surplus energy on the fuel market or use the land for other purposes such as food production. This extended approach is illustrated with a comprehensive case study demonstrating that with the RMC application it is possible to maximize the land use and to maximize the biofuel production for the requested energy demand.

11/02881 Regulatory, design and methodological impacts in determining tidal-in-stream power resource potential

Atwater, J. F. and Lawrence, G. A. *Energy Policy*, 2011, 39, (3), 1694–1698.

Tidal-in-stream energy has been heralded by many as a significant potential source for clean power, a scheme where kinetic energy is extracted from tidal currents. A number of estimates have suggested that tidal power may become a sizeable fraction of overall electricity generation, however these estimates have been largely based on a resource assessment methodology that dramatically oversimplifies the physical phenomenon at play. This paper develops a model that considers the effect of energy extraction on the bulk flow, showing that tidal energy inventories that assess solely kinetic energy flux may represent both an order-of-magnitude overestimation of the resource and a significant oversimplification of regulatory impacts. The interplay between the characteristics of a flow and the regulatory and economic issues will likely limit tidal power generation to levels significantly below the physical maximums. Permitted flow reduction, turbine design and staging of development all have significant and predictable impacts on the extractible resource. Energy planners must therefore understand these relationships in order to appropriately assess the magnitude of generation that can be realistically be produced from tidal energy.

11/02882 Renewable energy options for buildings: case studies

Rezaie, B. *et al. Energy and Buildings*, 2011, 43, (1), 56–65.

This paper deals with a novel approach to study renewable energy options for buildings to make them more efficient, more cost effective, more environmentally benign, and more technologically attractive. To demonstrate the application of this study, four buildings are chosen as case studies with two from the residential sector, one commercial/institutional building, and one industrial building. A ground source heat pump for heating and cooling, a solar water heater for space heating and/or hot water, and a photovoltaic panel to generate electricity are designed for these case studies. Attempt is made to design projects under hybrid systems combined from two technologies are developed for the above-mentioned four cases. Results obtained indicate that solar thermal option for hot water and space heating becomes the most cost effective one for all cases (e.g. $4956 for cases 1 and 2 and $70,652 for case 3, and $91,361 for case 4). In addition, solar electricity through PVs is technologically the most suitable one to meet the electricity demand. The ground source heat pump option is quite attractive from the efficiency and environmental impact point of views although it requires installation and maintenance, etc. Finally, hybrid systems provide better advantages, such as higher efficiency, reduced cost, reduced emissions, etc.

11/02883 The economics of renewable energy expansion in rural Sub-Saharan Africa

Deichmann, U. *et al. Energy Policy*, 2011, 39, (1), 215–227.

Accelerating development in Sub-Saharan Africa will require massive expansion of access to electricity – currently reaching only about one-third of households. This paper explores how essential economic development might be reconciled with the need to keep carbon emissions in check. The authors develop a geographically explicit framework and use spatial modelling and cost estimates from recent engineering studies to determine where stand-alone renewable energy generation is a cost effective alternative to centralized grid supply. The results suggest that decentralized renewable energy will likely play an important role in expanding rural energy access. However, it will be the lowest cost option for a minority of households in Africa, even when likely cost reductions over the next 20 years are considered. Decentralized renewables are competitive mostly in remote and rural areas, while grid connected supply dominates denser areas where the majority of households reside. These findings underscore the need to decarbonize the fuel mix for centralized power generation as it expands in Africa.

11/02884 The net cost of biofuels in Thailand – an economic analysis

Bell, D. R. *et al. Energy Policy*, 2011, 39, (2), 834–843.

Biofuels are expected to represent a growing portion of liquid fuel consumption in Thailand due to environmental and social considerations in conjunction with policy goals supporting their domestic production and consumption. This paper reviews the economic costs associated with biofuel policy implementation in Thailand in the short-term target year of 2011. Internal (production) and external (environmental, social, etc.) costs and benefits are evaluated, and, where possible, monetized. Domestic production of biofuel is calculated to be 9.5 billion baht (US$317 million) more expensive than importing the equivalent amount of petroleum. The environmental benefits from GHG savings as well as losses due to increased ground level ozone formation and government expenditure to support the biofuel industry yield a total 'net cost' of 8.6 billion baht or 121 baht ($4.04) per capita for the year 2011. This result is contextualized with the (non-monetized) consideration that although biofuels are somewhat more expensive in the short term, their domestic production allows virtually all of the money to stay within the Thai economy as opposed to being sent abroad. This fact, coupled with significant uncertainty in future petroleum prices, could strongly influence the direction of Thai policy with respect to biofuels.

11/02885 The renewable energy consumption – growth nexus in Central America

Apergis, N. and Payne, J. E. *Applied Energy*, 2011, 88, (1), 343–347.

This study examines the relationship between renewable energy consumption and economic growth for a panel of six Central American countries over the period 1980–2006. The heterogeneous panel cointegration test reveals a long-run equilibrium relationship between real GDP, renewable energy consumption, real gross fixed capital formation, and the labour force with the respective coefficients positive and statistically significant. The results from the panel error correction model indicate bidirectional causality between renewable energy consumption and economic growth in both the short and long run.

11/02886 Thermal modeling of a solid oxide fuel cell and micro gas turbine hybrid power system based on modified LS-SVM

Wu, X.-J. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 885–892.

For a solid oxide fuel cell (SOFC) integrated into a micro gas turbine (MGT) hybrid power system, SOFC operating temperature and turbine inlet temperature are the key parameters, which affect the performance of the hybrid system. Thus, a least squares support vector machine (LS-SVM) identification model based on an improved particle swarm optimization (PSO) algorithm is proposed to describe the non-linear temperature dynamic properties of the SOFC/MGT hybrid system in this paper. During the process of modelling, an improved PSO algorithm is employed to optimize the parameters of the LS-SVM. In order to obtain the training and prediction data to identify the modified LS-SVM model, a SOFC/MGT physical model is established via Simulink toolbox of MATLAB 6.5. Compared to the conventional BP neural network and the standard LS-SVM, the simulation results show that the modified LS-SVM model can efficiently reflect the temperature response of the SOFC/MGT hybrid system.

11/02887 Wood pellets production costs and energy consumption under different framework conditions in northeast Argentina

Uasuf, A. and Becker, G. *Biomass and Bioenergy*, 2011, 35, (3), 1357–1366.

The development of cleaner and renewable energy sources are needed in order to reduce dependency and global warming. Wood pellets are a clean renewable fuel and has been considered as one of the substitutes for fossil fuels. In Argentina, large quantities of sawmill residues are still unused and wood pellets production could be seen as both, as an environmental solution and an extra economical benefit. The general aim of this study was to determine the wood pellets production costs and energy consumption under different framework conditions in north-east Argentina. The specific costs of wood pellets for the different scenarios showed relative lower costs comparing to the ones reported in other studies, ranging from 35 to 47 €/Mg$_{\text{pellets}}$. Raw material costs represented the main cost factor in the calculation of the total pellets production costs. A lower specific production cost was observed when 50% of the raw material input was wood shavings. The specific electricity consumption per tonne of pellet was lower in scenarios with higher production rate. Lower heat energy consumption was observed in scenarios that have a mixed raw material input. The most promising framework condition for north-east Argentina, in terms of costs effectiveness and energy consumption could be acquired with production rates of 6 Mg/h with sawdust and wood shavings as raw material. However, simultaneous increment of the electricity by 50% and raw material price by 100% may increase the specific costs up to 50%.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

11/02888 3D CFD simulations of wind flow and wind-driven rain shelter in sports stadia: influence of stadium geometry

van Hooff, T. *et al. Building and Environment*, 2011, 46, (1), 22–37.

Sports stadia are increasingly used to host a wide variety of activities that attract large attendances, ranging from sports matches to concerts, festivities and conferences. One of the crucial aspects of spectator comfort in open stadia is protection from wind and rain. However, in many stadia this part of spectator comfort is insufficiently taken care of. The main reason is that stadia and stadium roofs are often designed with only vertical rainfall in mind, neglecting the influence of wind that can sweep the rain onto the stands. This wind-driven rain (WDR) can reach a large area of the stand underneath the roof, resulting in discomfort for the spectators in this area. For stadium design, it is important to understand the interaction between wind and rain in different types of stadium geometry and its effect on wetting of the stands. This paper presents three-dimensional (3D) computational fluid dynamics (CFD) simulations of wind flow and WDR for 12 different generic stadium configurations that are representative for a wide range of existing stadia. The wind-flow patterns are determined by steady-state Reynolds-averaged Navier–Stokes (RANS) simulations. The WDR trajectories are calculated using Lagrangian particle tracking, yielding the wetting pattern on the stands. This study demonstrates the influence of both overall stadium geometry and roof slope on the area of the stand that is wetted by WDR. It shows the importance of taking into account WDR in the stadium design process, and it provides some design guidelines to avoid this type of spectator discomfort.

11/02889 A comparison of the covariance matrix adaptation evolution strategy and the Levenberg–Marquardt method for solving multidimensional inverse transport problems

Bledsoe, K. C. *et al. Annals of Nuclear Energy*, 2011, 38, (4), 897–904.

The covariance matrix adaptation evolution strategy (CMA-ES), a powerful optimization algorithm that mimics the process of evolution in nature, is applied to the inverse transport problems of interface location identification, source composition identification, and material mass density identification (both separately and combined) in cylindrical radioactive source/shield systems. The energies of discrete gamma-ray lines emitted by the source are assumed to be known, while the uncollided line fluxes are assumed to be measured at points external to the system. CMA-ES is compared to the Levenberg–Marquardt method, a standard gradient-based optimization algorithm, on numerical test cases using both simulated data that is perfectly consistent with the optimization process and with realistic data simulated by Monte Carlo. Numerical results indicate that the Levenberg–Marquardt method is more adept at problems with few unknowns (i.e. ≤ 3), but as the number of unknowns increases, CMA-ES becomes the superior strategy. Results also indicate that a parallel version of CMA-ES would be more robust than, and have competitive run times with, the Levenberg–Marquardt method for many inverse transport problems.

11/02890 A heuristic-based approach for reliability importance assessment of energy producers

Akhavein, A. and Firuzabad, M. F. *Energy Policy*, 2011, 39, (3), 1562–1568.

Reliability of energy supply is one of the most important issues of service quality. On one hand, customers usually have different expectations for service reliability and price. On the other hand, providing different level of reliability at load points is a challenge for system operators. In order to take reasonable decisions and obviate reliability implementation difficulties, market players need to know impacts of their assets on system and load-point reliabilities. One tool to specify reliability impacts of assets is the criticality or reliability importance measure by which system components can be ranked based on their effect on reliability. Conventional methods for determination of reliability importance are essentially on the basis of risk sensitivity analysis and hence, impose prohibitive calculation burden in large power systems. An approach is proposed in this paper to determine reliability importance of energy producers from perspective of consumers or distribution companies in a composite generation and transmission system. In the presented method, while avoiding immense computational burden, the energy producers are ranked based on their rating, unavailability and impact on power flows in the lines connecting to the considered load points. Study results on the IEEE reliability test system show successful application of the proposed method.

11/02891 A new honey bee mating optimization algorithm for non-smooth economic dispatch

Niknam, T. *et al. Energy*, 2011, 36, (2), 896–908.

The non-storage characteristics of electricity and the increasing fuel costs worldwide call for the need to operate the systems more economically. Economic dispatch (ED) is one of the most important optimization problems in power systems. ED has the objective of dividing the power demand among the online generators economically while satisfying various constraints. The importance of economic dispatch is to get maximum usable power using minimum resources. To solve the static ED problem, honey bee mating algorithm (HBMO) can be used. The basic disadvantage of the original HBMO algorithm is the fact that it may miss the optimum and provide a near optimum solution in a limited runtime period. In order to avoid this shortcoming, a new method was proposed that improves the mating process of HBMO and also, combines the improved HBMO with a chaotic local search (CLS) called chaotic improved honey bee mating optimization (CIHBMO). The proposed algorithm is used to solve ED problems taking into account the non-linear generator characteristics such as prohibited operation zones, multi-fuel and valve-point loading effects. The CIHBMO algorithm is tested on three test systems and compared with other methods in the literature. Results have shown that the proposed method is efficient and fast for ED problems with non-smooth and non-continuous fuel cost functions. Moreover, the optimal power dispatch obtained by the algorithm is superior to previous reported results.

11/02892 A simplified mathematical model for urban microclimate simulation

Yao, R. *et al. Building and Environment*, 2011, 46, (1), 253–265.

Techniques for modelling urban microclimates and urban block surfaces temperatures are desired by urban planners and architects for strategic urban designs at the early design stages. This paper introduces a simplified mathematical model for urban simulations (UMsim) including urban surfaces temperatures and microclimates. The nodal network model has been developed by integrating coupled thermal and airflow model. Direct solar radiation, diffuse radiation, reflected radiation, long-wave radiation, heat convection in air and heat transfer in the exterior walls and ground within the complex have been taken into account. The relevant equations have been solved using the finite difference method under the Matlab platform. Comparisons have been conducted between the data produced from the simulation and that from an urban experimental study carried out in a real architectural complex on the campus of Chongqing University, China in July 2005 and January 2006. The results show a satisfactory agreement between the two sets of data. The UMsim can be used to simulate the microclimates, in particular the surface temperatures of urban blocks, therefore it can be used to assess the impact of urban surfaces properties on urban microclimates. The UMsim will be able to produce robust data and images of urban environments for sustainable urban design.

11/02893 An efficient Monte Carlo-subsampling approach to first passage problems

Marseguerra, M. *Annals of Nuclear Energy*, 2011, 38, (2–3), 410–417.

In the realm of the continuous time random walk (CTRW) and in conjunction with the Monte Carlo (MC) approach, the authors consider the transport of a chemical or radioactive pollutant in a three-dimensional heterogeneous medium, focusing on the first passage time (FPT), defined as the time required by the walkers representative of the dangerous particles to travel within the medium until crossing a target disk, thus entering another medium which should instead remain clean, such as a water well or an aquifer. The advantage of the MC approach is the possibility of simulating different features of the travel such as different waiting-time probabilities, space dependent jump lengths, absorption and desorption phenomena, Galilei invariant and variant velocities driven by external forces. When the computer time required for collecting a suitable number of target crossings is excessive, the authors propound to hybridize the MC approach with the recent subsampling computational procedure, usefully applied in the engineering reliability field to computing very small failure probabilities in short computer time. To tackle the FPT problem groups of a few thousands of walkers were iteratively considered: in each iteration a fraction of those closer to the target were selected, ignoring the remaining ones, and then the group was restored by creating with the MC technique new walkers even more close to the target. The successive groups have large conditional probabilities which can be estimated one after the other in a short time and whose product yields the total probability. By so doing the FPT can be actually computed in much shorter times: examples are reported of Gaussian and anomalous distributions in which the reduction with respect to a pure MC computation is of orders of magnitude.

11/02894 Artificial neural network analysis of liquid desiccant dehumidification system

Gandhidasan, P. and Mohandes, M. A. *Energy*, 2011, 36, (2), 1180–1186.

The dehumidification process involves simultaneous heat and mass transfer and reliable transfer coefficients are required in order to analyse the system. This has been proved to be difficult and many assumptions are made to simplify the analysis. The present research proposes the use of artificial neural network (ANN)-based model in order to simulate the relationship between inlet and outlet parameters of the dehumidifier. For the analysis, randomly packed dehumidifier with lithium chloride as the liquid desiccant is chosen. A multilayer ANN is used to investigate the performance of dehumidifier. For training ANN models, data is obtained from analytical equations. Eight parameters are used as inputs to the ANN, namely: air and desiccant flow rates, air and desiccant inlet temperatures, air inlet humidity, desiccant inlet concentration, dimensionless temperature ratio, and inlet temperature of the cooling water. The outputs of the ANN are the water condensation rate and the outlet desiccant concentration as well as its temperature. ANN predictions for these parameters are validated well with experimental values available in the literature with R^2 value in the range of 0.9251–0.9660. This study shows that liquid desiccant dehumidification system can be alternatively modelled using ANN with a reasonable degree of accuracy.

11/02895 Automatic computation for optimum height planning of apartment buildings to improve solar access

Seong, Y.-B. *et al. Solar Energy*, 2011, 85, (1), 154–173.

The objective of this study is to suggest a mathematical model and an optimal algorithm for determining the height of apartment buildings to satisfy the solar rights of survey buildings or survey housing units. The objective is also to develop an automatic computation model for the optimum height of apartment buildings and then to clarify the performance and expected effects. To accomplish the objective of this study, the following procedures were followed: (1) the necessity of the height planning of obstruction buildings to satisfy the solar rights of survey buildings or survey housing units is demonstrated by analysing through a literature review the recent trend of disputes related to solar rights and to examining the social requirements in terms of solar rights. In addition, the necessity of the automatic computation system for height planning of apartment buildings is demonstrated and a suitable analysis method for this system is chosen by investigating the characteristics of analysis methods for solar rights assessment. (2) A case study on the process of height planning of apartment buildings will be briefly described and the problems occurring in this process will then be examined carefully. (3) To develop an automatic computation model for height planning of apartment buildings, geometrical elements forming apartment buildings are defined by analysing the geometrical characteristics of apartment buildings. In addition, design factors and regulations required in height planning of apartment buildings are investigated. Based on this knowledge, the methodology and mathematical algorithm to adjust the height of apartment buildings by automatic computation are suggested and probable problems and the ways to resolve these problems are discussed. Finally, the methodology and algorithm for the optimization are suggested. (4) Based on the suggested methodology and mathematical algorithm, the automatic computation model for optimum height of apartment buildings is developed and the developed system is verified through the application of some cases. The effects of the suggested model are then demonstrated quantitatively and qualitatively.

11/02896 CFD analysis of heat collection in a glazed gallery

Suárez, M. J. *et al. Energy and Buildings*, 2011, 43, (1), 108–116.

A glazed gallery in most old buildings is a space located on the first floor (and/or higher floors), facing south and almost fully glazed. As a result of the large glazed area and the orientation of the gallery, its temperature is warmer than the exterior and, in cold weather, it is used both as a space to insulate the adjacent rooms and as a leisure area, among other applications. In the framework of the ARFRISOL project (bioclimatic architecture and solar cooling), a demonstration container has been constructed in northern Spain (Asturias) which includes, among other bioclimatic elements, a glazed gallery. This gallery is considered as an element of bioclimatic architecture that enables solar radiation to be collected and the energy obtained to be used to support the building's air conditioning system. It consists of a south-facing glazed exterior wall, an intermediate space or passage and a partially glazed interior wall. Dampers located in the floor and ceiling of the intermediate space and connected to the air ducts enable the air circulating inside the gallery to be heated or cooled, depending on the season of the year, before it is further conditioned and conveyed to the rooms. This paper focuses on the three-dimensional numerical simulation of the airflow inside the gallery. The aim is to obtain a model to evaluate the thermal energy obtained in this architectural feature, integrating the effect of certain variables, such as the incident solar irradiation, the outdoor temperature and the air flow rate circulating in the gallery.

11/02897 Combustion of butanol isomers – a detailed molecular beam mass spectrometry investigation of their flame chemistry

Oßwald, P. *et al. Combustion and Flame*, 2011, 158, (1), 2–15.

The combustion chemistry of the four butanol isomers, 1-, 2-, *iso*- and *tert*-butanol was studied in flat, premixed, laminar low-pressure (40 mbar) flames of the respective alcohols. Fuel-rich ($\phi = 1.7$) butanol–oxygen–(25%) argon flames were investigated using different molecular beam mass spectrometry (MBMS) techniques. Quantitative mole fraction profiles are reported as a function of burner distance. In total, 57 chemical compounds, including radical and isomeric species, have been unambiguously assigned and detected quantitatively in each flame using a combination of vacuum ultraviolet (VUV) photoionization (PI) and electron ionization (EI) MBMS. Synchrotron-based PI-MBMS allowed to separate isomeric combustion intermediates according to their different ionization thresholds. Complementary measurements in the same flames with a high mass-resolution EI-MBMS system provided the exact elementary composition of the involved species. Resulting mole fraction profiles from both instruments are generally in good quantitative agreement. In these flames of the four butanol isomers, temperature, measured by laser-induced fluorescence (LIF) of seeded nitric oxide, and major species profiles are strikingly similar, indicating seemingly analogue global combustion behaviour. However, significant variations in the intermediate species pool are observed between the fuels and discussed with respect to fuel-specific destruction pathways. As a consequence, different, fuel-specific pollutant emissions may be expected, by both their chemical nature and concentrations. The results reported here are the first of their kind from premixed isomeric butanol flames and are thought to be valuable for improving existing kinetic combustion models.

11/02898 Coordinated preventive control of transient stability with multi-contingency in power systems using trajectory sensitivities

Li, Y. H. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (1), 147–153.

In this paper, the challenging multi-contingency transient stability constrained optimal power flow problem is partitioned into two sub-problems, namely optimal power flow (OPF) and transient stability control, solved in turn with conventional well trusted power system analysis tools instead of tackling it directly using a complicated integrated approach. Preventive multi-contingency transient stability control is carried out with generation rescheduling based on trajectory sensitivities using results obtained from a conventional transient stability simulation. A new iterative approach is proposed to optimally redistribute the generation from the critical machines to non-critical machines with the help of conventional OPF. Results on the New England 10-machine 39-bus systems demonstrate that the proposed method is capable of handling multiple contingencies and complex power system models effectively with solution quantity and time comparable with conventional integrated approaches.

11/02899 Development of a cost effective probe for the long term monitoring of straw bale buildings

Carfrae, J. *et al. Building and Environment*, 2011, 46, (1), 156–164.

This paper reviews current methodologies for measuring the moisture content of straw bale walls in buildings. It discusses the development of an affordable and accurate moisture probe that has been designed to be easily assembled by the builder or owner of a straw bale building from items readily available in the UK. The probe uses a timber block inserted into the wall, relying upon the measurable moisture variances of the timber and relating this to the surrounding straw. The probes are designed to be used in pairs of varying length, taking measurements at different depths to give an estimate of the moisture gradient through the wall. In order to properly calibrate this device, a full set of sorption and desorption isotherms were established for both oat and wheat straw and three different timber species. The results from an environmental chamber have been compared to readings from specimens of the new probe installed in a straw bale house in the south-west of the UK. The results were found to be consistent, to within 2%, with the laboratory findings.

11/02900 Development of a framework for a high-resolution, three-dimensional regional air quality simulation and its application to predicting future air quality over Japan

Chatani, S. *et al. Atmospheric Environment*, 2011, 45, (7), 1383–1393.

The authors have developed a framework for a three-dimensional regional air quality simulation that is applicable to various air quality studies over Japan. The framework consists of the following simulation model systems: the weather research and forecasting (WRF) model to simulate meteorological fields; the community multi-scale air quality (CMAQ) modelling system to simulate pollutant concentrations; emissions estimate models; and emission databases. Motor vehicle emissions in Japan are estimated using the Japan auto-oil program (JATOP) vehicle emissions estimate model; anthropogenic emissions from sources other than motor vehicles in Japan are estimated using the georeference-based emission activity modelling System (G-BEAMS); and biogenic emissions are estimated using the model of emissions of gases and aerosols from nature (MEGAN). The regional emission inventory in Asia (REAS) is used for emissions in Asian countries except for Japan. The most prominent feature of this framework is its ability to simulate multi-scale air quality. The framework allows for the simulation of emissions and the dynamic transport of pollutants in heavily polluted urban areas with a maximum resolution of 1 × 1 km, and the long-range transport of pollutants is also taken into account. This framework is used to analyse the impact of future emissions from anthropogenic sources on air quality over the Tokyo metropolitan area. NO_x, NMVOC and primary $PM_{2.5}$ emissions over the Tokyo metropolitan area are estimated to be reduced by 44.5%, 18.1% and 41.7%, respectively, from 2005 to 2020. The simulation predicts that concentrations of NO_2 and $PM_{2.5}$ over the Tokyo metropolitan area will decrease by approximately 30–40% and 15–20%, respectively, during the above period. O_3 concentrations significantly increase in winter due to decreased titration by NO, whereas no significant variations are observed in spring and summer. In addition, the impact of future long-range transport projected under three emission scenarios provided by REAS was analysed. The simulation indicates that future long-range transport will affect concentrations of O_3 and $PM_{2.5}$ over the Tokyo metropolitan area; however, its impact is small compared with that of future anthropogenic emissions in Japan.

11/02901 Efficient solution algorithms for computing fold points of power flow equations

Yang, X. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (2), 229–235.

Techniques for identifying fold points of power flow equations are fundamental to voltage stability analysis. This paper presents efficient methods for computing fold points of power flow equations. The proposed methods make use of two generalized extended systems for determining fold points of non-linear systems, i.e. the Moore–Spence system and the minimally extended system. Block elimination (BE) techniques are used in the solution procedures for the two systems. Hence, the sparsity of Jacobian matrix of power flow equations can be fully exploited to enhance computational efficiency. Left and right singular vectors corresponding to the zero eigenvalue of Jacobian matrix of non-linear power flow equations can be obtained simultaneously at the end of the iterations. Numerical examples of Ward & Hale 6-bus system and a real 1620-bus power system in China are presented to validate the methods.

11/02902 Empirical correlating equations for predicting the effective thermal conductivity and dynamic viscosity of nanofluids

Corcione, M. *Energy Conversion and Management*, 2011, 52, (1), 789–793.

In this paper, two empirical correlations for predicting the effective thermal conductivity and dynamic viscosity of nanofluids, based on a high number of experimental data available in the literature, are proposed and discussed. It is found that, given the nanoparticle material and the base fluid, the ratio between the thermal conductivities of the nanofluid and the pure base liquid increases as the nanoparticle volume fraction and the temperature are increased, and the nanoparticle diameter is decreased. Additionally, also the ratio between the dynamic viscosities of the nanofluid and the pure base liquid increases as the nanoparticle volume fraction is increased, and the nanoparticle diameter is decreased, being practically independent of temperature. The ease of application of the equations proposed, and their wide regions of validity (the ranges of the nanoparticle diameter, volume fraction and temperature are 10–150 nm, 0.002–0.09 and 294–324 K for the thermal conductivity data, and 25–200 nm, 0.0001–0.071 and 293–323 K for the dynamic viscosity data), make such equations useful by the engineering point of view, for both numerical simulation purposes and thermal design tasks.

11/02903 Forecasting energy consumption using a grey model improved by incorporating genetic programming

Lee, Y.-S. and Tong, L.-I. *Energy Conversion and Management*, 2011, 52, (1), 147–152.

Energy consumption is an important economic index, which reflects the industrial development of a city or a country. Forecasting energy consumption by conventional statistical methods usually requires the making of assumptions such as the normal distribution of energy consumption data or on a large sample size. However, the data collected on energy consumption are often very few or non-normal. Since a grey forecasting model, based on grey theory, can be constructed for at least four data points or ambiguity data, it can be adopted to forecast energy consumption. In some cases, however, a grey forecasting model may yield large forecasting errors. To minimize such errors, this study develops an improved grey forecasting model, which combines residual modification with genetic programming sign estimation. Finally, a real case of Chinese energy consumption is considered to demonstrate the effectiveness of the proposed forecasting model.

11/02904 Generation expansion planning in pool market: a hybrid modified game theory and particle swarm optimization

Moghddas-Tafreshi, S. M. *et al. Energy Conversion and Management*, 2011, 52, (2), 1512–1519.

Unlike the traditional policy, generation expansion planning (GEP) problem in competitive framework is complicated. In the new policy, each generation company (GENCO) decides to invest in such a way that obtains as much profit as possible. This paper presents a new hybrid algorithm to determine GEP in a Pool market. The proposed algorithm is divided in two programming levels: master and slave. In the master level a modified game theory (MGT) is proposed to evaluate the contrast of GENCOs by the independent system operator (ISO). In the slave level, a particle swarm optimization (PSO) method is used to find the best solution of each GENCO for decision-making of investment. The validity of the proposed method is examined in the case study including three GENCOs with multi-types of power plants. The results show that the presented method is both satisfactory and consistent with expectation.

11/02905 Heat release rate calculation in oxygen consumption calorimetry

Chow, W. K. and Han, S. S. *Applied Thermal Engineering*, 2011, 31, (2–3), 304–310.

Heat release rates of burning combustibles in bench-scale, medium-scale and large-scale experiments are now commonly measured by the oxygen consumption method. As the equations commonly used in the literature might not be appropriate for some conditions, a general equation including mole fractions of six components on nitrogen, oxygen, carbon dioxide, carbon monoxide, soot and water vapour is presented in this paper. Difference in flow rates between the intake and exhaust gases is introduced for correction on incomplete combustion. The general equation can be simplified easily as other expressions under various conditions. Application of the equations for some special environments is illustrated.

11/02906 Hybrid carbon nanostructured ensembles as chemiresistive hydrogen gas sensors

Kaniyoor, A. and Ramaprabhu, S. *Carbon*, 2011, 49, (1), 227–236.

Hybrid carbon nanostructures consisting of graphene nanoplatelets (GNPs) interspersed with multiwalled carbon nanotubes (MWCNTs) were synthesized by solution phase mixing of their parent aqueous dispersions. To further arrest the aggregation of GNPs, crystalline nanoparticles of a noble metal (Pt) were dispersed *in situ* by chemical reduction. This ensemble of the metal decorated hybrid structure was solubilized using Nafion and a simple drop casting method was employed to fabricate the sensor. In addition to the remarkable stability and repeatability, the sensor also showed an enhanced sensitivity of approximately 17% to a low concentration of 4 vol.% hydrogen in air, at room temperature. The improved sensitivity due to Nafion solubilization could be explained by a dual mechanism of hydrogen dissociation. Variations in the sensor properties with change in hydrogen concentrations and temperature were studied. The kinetics of hydrogen adsorption in the sensor could be well explained by the Avrami–Erofeev model. From the Arrhenius plot of the rate constants, the activation energy was determined to be ~24 kJ/(mol H). Effect of morphology of the bare hybrid structure was systematically investigated by varying the weight ratios of GNPs and MWCNTs.

11/02907 Important sensors for chiller fault detection and diagnosis (FDD) from the perspective of feature selection and machine learning

Han, H. *et al. International Journal of Refrigeration*, 2011, 34, (2), 586–599.

The benefits of applying automated fault detection and diagnosis (AFDD) to chillers include less expensive repairs, timely maintenance, and shorter downtimes. This study employs feature selection (FS) techniques, such as mutual-information-based filter and genetic-algorithm-based wrapper, to help search for the important sensors in data driven chiller FDD applications, so as to improve FDD performance while saving initial sensor cost. The ‘one-against-one’ multi-class support vector machine (SVM) is adopted as a FDD tool. The results show that the eight features/sensors, centred around the core refrigeration cycle and selected by the GA-SVM wrapper from the original 64 features, outperform the other three feature subsets by the GA-LDA (linear discriminant analysis) wrapper, with an overall classification correct rate (CR) as high as 99.53% for the 4000 test samples randomly covering the normal and seven typical faulty modes. The CRs for the four cases with FS are all higher than that without FS (97.45%) and the test time is much less, about 28–36%. The FDD performance for normal or each of the faulty modes is also evaluated in details in terms of hit rate and false alarm rate.

11/02908 In situ estimation of roof rock strength using sonic logging

Oyler, D. C. *et al. International Journal of Coal Geology*, 2010, 83, (4), 484–490.

Sonic travel time logging of exploration boreholes is routinely used in Australia to obtain estimates of coal mine roof rock strength. Because sonic velocity logs are relatively inexpensive and easy to obtain during exploration, the technique has provided Australian underground coal mines with an abundance of rock strength data for use in all aspects of ground control design. However, the technique depends on reliable correlations between the uniaxial compressive strength (UCS) and the sonic velocity. This paper describes research recently conducted by NIOSH aimed at developing a correlation for use by the US mining industry. From two coreholes in Illinois, two from Pennsylvania, and one each from Colorado, western Kentucky and southern West Virginia, sonic velocity logs were compared with UCS values derived from point load tests for a broad range of coal measure rock types. For the entire data set, the relationship between UCS and sonic travel time is expressed by an exponential equation relating the UCS in psi to the travel time of the P-wave in μs/ft. The coefficient of determination or *R*-squared for this equation is 0.72, indicating that a relatively high reliability can be achieved with this technique. The strength estimates obtained from the correlation equation may be used to help design roof support systems. The paper also addresses the steps that are necessary to ensure that high-quality sonic logs are obtained for use in estimating UCS.

11/02909 Investigation of thermal stratification in cisterns using analytical and artificial neural networks methods

Ameri Siahoui, H. R. *et al. Energy Conversion and Management*, 2011, 52, (1), 505–511.

The thermal characteristics of an underground cold-water reservoir are investigated analytically and using artificial neural networks (ANN). An analytical solution is developed for the temperature distribution in the reservoir by assuming a linearized boundary condition at the water surface. For the general non-linear boundary condition, the temperature distribution is modelled using ANN. Very good agreements between the analytical and ANN results at various times during the withdrawal cycle are observed, ensuring the accuracy of the analytical and ANN procedures. The results show that a stable thermal stratification is preserved in the reservoir throughout the entire course of withdrawal cycle. As one important outcome of this research, two different regions are observed inside the thermally stratified tank during discharge cycle. The bottom region with a linear temperature distribution and the upper one in which a nearly exponential thermal stratification are developed. During withdrawal cycle, the outside temperature reaches as high as 42 °C, while cool water with the temperature varying from 12 to 13 °C is easily available from the underground water reservoir under investigation.

11/02910 Multi-objective shape optimization of helico-axial multiphase pump impeller based on NSGA-II and ANN

Zhang, J. *et al. Energy Conversion and Management*, 2011, 52, (1), 538–546.

In order to improve the prototype's performance of the helico-axial multiphase pump, a multi-objective optimal method for the pump impeller was developed by combining the artificial neural network (ANN) with non-dominated sorting genetic algorithm-II (NSGA-II). The main geometric parameters influencing the impeller's performance were chosen as the optimization variables, and the sample spaces were structured according to the orthogonal experimental design method. Then the pressure rise and efficiency in specific working conditions were obtained about all the elements in the sample space by numerical simulation. With the simulated results as the input specimen, a multiphase pump performance prediction model was designed through BP neural network. With the obtained prediction model as the fitness value evaluation method, the pump impeller was optimized using the NSGA-II multi-objective genetic algorithm, which finally offered an improved impeller structure with enhanced pressure rise and efficiency. Furthermore, five stages of optimized compression cells were manufactured and applied in experiment test. The result shows compared to the original design, the pressure rise of the optimized pump has increased by 10% and the efficiency has increased by $\sim$3%, which is in keeping with the optimal result and confirms the method is feasible.

11/02911 Novel application for exergy and thermoeconomic analysis of processes simulated with Aspen Plus

Querol, E. *et al. Energy*, 2011, 36, (2), 964–974.

A visual basic application for Microsoft Excel 2007 has been developed as a helpful tool to perform mass, energy, exergy and thermoeconomic (MHBT) calculations during the systematic analysis of energy processes simulated with Aspen Plus. The application reads an Excel workbook containing three sheets with the matter, work and heat streams results of an Aspen Plus simulation. The required information from the Aspen Plus simulation and the algorithm/calculations of the application are described and applied to an air separation unit (ASU). This application helps the designer when MHBT analyses are performed, as it increases the knowledge of the process simulated with Aspen Plus. It is a valuable tool not only because of the calculations performed, but also because it creates a new Excel workbook where the results and the formulae written on the cells are fully visible and editable. There is free access to the application and it has no protection allowing changes and improvements to be done.

11/02912 Numerical simulation of gas flow through porous sandstone and its experimental validation

Perera, M. S. A. *et al. Fuel*, 2011, 90, (2), 547–554.

Due to post-lithogenetic fracturing or weathering, sandstone can contain complex dual porosity structure, which makes it difficult to identify the fluid flow behaviour through it. The main objective of this study is to develop a three dimensional numerical model to simulate the flow of gas through porous sandstone under triaxial test condition. For the purpose of the modelling study, laboratory data which have been obtained from triaxial experiments conducted on porous sandstone samples were used. In this study, a commercial reservoir simulator, COMET 3 was used to model the gas flow in the test samples. The COMET 3 model closely predicts the gas flow through the porous sandstone sample for the range of confining and gas injection pressures studied in the laboratory and for low gas flow rates (laminar flow). However the model fails at high flow rates (turbulent flows), due to the fact that the COMET 3 simulator uses Darcy's law for flow simulations. Therefore, caution is required when interpreting the model results if the assumption of laminar flow does not apply to the flow conditions. An empirical relationship has been developed in this study which can be used to obtain an estimation of the flowrate when the flow has become non-Darcian. It is however important to be able to identify the transition point from Darcy to non-Darcy flow when the assumption of Darcian flow in COMET 3 no longer applies. Experiments conducted elsewhere clearly showed the transition points which are dependent on the injection and confining pressures. The model developed using COMET 3 appeared to give better prediction of the gas flow rate in sandstone sample, under triaxial test condition, than the earlier COMSOL multiphysics model.

11/02913 On developing a prospecting tool for wind industry and policy decision support

McKeown, C. *et al. Energy Policy*, 2011, 39, (2), 905–915.

This paper presents the rudiments of a wind prospecting tool designed to inform private and public decision makers involved in wind industry development in reducing transaction costs associated with identifying areas of mutual focus within a state. The multiple layer decision support framework has proven to be valuable to industry, state government and local decision makers. Information on wind resources, land availability, potential land costs, potential NIMBYism concerns and economic development potential were integrated to develop a framework for decision support. The paper also highlights implications for decision support research and the role of higher education in providing anticipatory science to enhance private and public choices in economic development.

11/02914 On-line spectroscopic and spectrometric methods for the determination of metal species in industrial processes

Monkhouse, P. *Progress in Energy and Combustion Science*, 2011, 37, (2), 125–171.

The status of on-line methods for determining metal species, particularly alkali and heavy metals, is reviewed. The background and motivation is discussed first, including current environmental and economic issues associated with release of metal species in industrial processes as well as control measures. Then general diagnostic problems such as optical access and sampling design are considered, followed by an overview of selected diagnostic methods, including recent contributions to technique development and to the understanding of fundamental combustion processes. The main focus is on absorption (tunable diode laser and differential absorption spectroscopies) and emission (spontaneous atomic emission, laser induced fluorescence, photofragment fluorescence as well as several varieties of plasma spectroscopy), but on-line ionization methods (molecular beam and single particle mass spectrometry and surface ionization) are also reviewed briefly. In the final section, the capabilities of the selected methods are illustrated by examples of field measurements in the conversion of solid fuels as well as waste incineration, glass production and other processes.

11/02915 On-road instantaneous speed measurements on powered two-wheelers for exhaust emissions and fuel consumption evaluation

Zamboni, G. *et al. Energy*, 2011, 36, (2), 1039–1047.

An experimental investigation on instantaneous speed measurements with instrumented motorcycles was performed considering three typical urban trips, divided in twelve sections according to different road classes. The main kinematic parameters obtained by processing experimental values are presented and compared with those referred to standard cycles, confirming that real world driving conditions are hardly reproduced by statutory cycles. Several applications of measured data are then analysed. Exhaust emission and fuel consumption factors were calculated for different motorcycle classes by applying the functions of Copert, Artemis and Progress models and the Artemis traffic situation approach, considering typical average speed levels and the experimental values. Results are then compared in order to highlight the differences between applied functions and methodologies. A selection of speed profiles was also performed in order to define the emissive behaviour of two-wheelers on the chassis dynamometer: experimental emission and consumption factors for a Euro 3 scooter are related to calculated levels, while measured cold and hot exhaust emissions and fuel consumption of a Euro 2 moped are compared with the results obtained on standard and real-world driving cycles, proving that the new speed patterns may be useful to define emissions and fuel consumption of these vehicles.

11/02916 Parameters identification of hydraulic turbine governing system using improved gravitational search algorithm

Li, C. and Zhou, J. *Energy Conversion and Management*, 2011, 52, (1), 374–381.

Parameter identification of hydraulic turbine governing system (HTGS) is crucial in precise modelling of hydropower plant and provides support for the analysis of stability of power system. In this paper, a newly developed optimization algorithm, called gravitational search algorithm (GSA), is introduced and applied in parameter identification of HTGS, and the GSA is improved by combination of the search strategy of particle swarm optimization. Furthermore, a new weighted objective function is proposed in the identification frame. The improved gravitational search algorithm (IGSA), together with genetic algorithm, particle swarm optimization and GSA, is employed in parameter identification experiments and the procedure is validated by comparing experimental and simulated results. Consequently, IGSA is shown to locate more precise parameter values than the compared methods with higher efficiency.

11/02917 Performance monitoring of direct air-cooled power generating unit with infrared thermography

Ge, Z. *et al. Applied Thermal Engineering*, 2011, 31, (4), 418–424.

Infrared thermography technique was employed to monitor overall as well as local surface temperature distributions of air-cooled condensers (ACC) in order to investigate the influence of ambient air temperatures, surface fouling of fin-tube bundles and natural wind on performance of air-cooled power generating units. Three typical direct air-cooled power generating units in operation in north China were selected as the research objects, which are 300 MW sub-critical units with ACC of three-row fin-tube bundles, 600 MW sub-critical unit and 600 MW supercritical unit with ACC of single-row fin-tube bundle respectively. The monitoring results revealed that the counterflow ACC units were vulnerable to freezing in winter. The results also cast light on the uneven steam flow distributions inside fin-tubes of different parallel-flow ACC units, especially when the redundant cooling areas of ACC island were large. The characteristics of surface temperature distributions were obtained in different regions of ACC units under surface fouling conditions. It was also acquired that the gentle natural wind can have an impact on the heat transfer of most cooling areas of ACC island by forming overhead vortex. This should be paid attention to as well as besides the effect of thermal recirculation under large natural wind conditions. The present study may benefit the optimal operation of air-cooled power generating units.

11/02918 Predicting the net heat of combustion of organic compounds from molecular structures based on ant colony optimization

Pan, Y. *et al. Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 85–89.

A quantitative structure–property relationship (QSPR) model for prediction of standard net heat of combustion was developed from molecular structures. A diverse set of 1650 organic compounds were employed as the studied dataset, and a total of 1481 molecular descriptors were calculated for each compound. The novel variable selection method of ant colony optimization (ACO) algorithm coupled with the partial least square (PLS) was employed to select optimal subset of descriptors that have significant contribution to the overall property of standard net heat of combustion from the large pool of calculated descriptors. As a result, four molecular descriptors were screened out as the input parameters, and a four-variable multi-linear model was finally constructed using multi-linear regression (MLR) method. The resulted squared correlation coefficient R^2 of the model was 0.995 for the training set of 1322 compounds, and 0.996 for the external test set of 328 compounds, respectively. The results showed that an accurate prediction model for the net heat of combustion could be obtained by using the ant colony optimization method. Moreover, this study can provide a new way for predicting the net heat of combustion of organic compounds for engineering based on only their molecular structures.

11/02919 Towards spatial geochemical modelling: use of geographically weighted regression for mapping soil organic carbon contents in Ireland

Zhang, C. *et al. Applied Geochemistry*, 2011, 26, (7), 1239–1248.

Soil organic carbon (SOC) distribution maps are required for improvements in soil management and for the estimation of carbon stocks at regional scales. This study investigates the use of a geographically weighted regression (GWR) method for the spatial modelling of SOC in Ireland. A total of 1310 samples of SOC data were extracted from the National Soil Database of Ireland. Environmental factors of rainfall, land cover and soil type were investigated and included as the independent variables to establish the GWR model. The GWR provided comparable and reasonable results with the other chosen methods of ordinary kriging (OK), inverse distance weighted (IDW) and multiple linear regression (MLR). The SOC map produced using the GWR model showed clear spatial patterns influenced by environmental factors and the smoothing effect of spatial interpolation was reduced. This study has demonstrated that GWR provides a promising method for spatial geochemical modelling of SOC and potentially other geochemical parameters.

11/02920 Very short-term wind speed prediction: a new artificial neural network–Markov chain model

Kani, S. A. P. and Ardehali, M. M. *Energy Conversion and Management*, 2011, 52, (1), 738–745.

As the objective of this study, artificial neural network (ANN) and Markov chain (MC) are used to develop a new ANN–MC model for forecasting wind speed in very short-term time scale. For prediction of very short-term wind speed in a few seconds in the future, data patterns for short-term (about an hour) and very short-term (about minutes or seconds) recorded prior to current time are considered. In this study, the short-term patterns in wind speed data are captured by ANN and the long-term patterns are considered utilizing MC approach and four neighbourhood indices. The results are validated and the effectiveness of the new ANN–MC model is demonstrated. It is found that the prediction errors can be decreased, while the uncertainty of the predictions and calculation time are reduced.

Fuel cell technology

11/02921 A new soft switched push pull current fed converter for fuel cell applications

Delshad, M. and Farzanehfard, H. *Energy Conversion and Management*, 2011, 52, (2), 917–923.

In this paper a new zero voltage switching current fed push-pull dc–dc converter is proposed for fuel cell generation system. The auxiliary circuit in this converter, not only absorbs the voltage surge across the switches at turn off instance, but also provides zero voltage switching condition for all converter switches. Therefore, the converter efficiency is increased and size and weight of the converter can be decreased. Also implementation of control circuit is very simple since the converter is PWM controlled. In this paper, the proposed dc–dc converter operating modes are analysed and to verify the converter operation a laboratory prototype is implemented and the experimental results are presented.

11/02922 A novel electronic current-blocked stable mixed ionic conductor for solid oxide fuel cells

Sun, W. *et al. Journal of Power Sources*, 2011, 196, (1), 62–68.

A novel ionic conductor, $BaCe_{0.8}Sm_{0.2}O_{3-\delta}$–$Ce_{0.8}Sm_{0.2}O_{2-\delta}$ (BCS–SDC, weight ratio 1:1), is reported as an electrolyte material for solid oxide fuel cells (SOFCs). Homogeneous BCS–SDC composite powders are synthesized via a one-step gel combustion method. The BCS and SDC crystalline grains play a role as matrix for each other in the composite electrolyte. The composite avoids the typical drawbacks of BCS and SDC, showing not only a better chemical stability than the single phase of BCS but much higher open circuit voltages (OCVs) than the single phase of SDC under the fuel cell conditions. Moreover, BCS–SDC exhibits mixed oxygen ionic and protonic conduction. A total conductivity of $0.0204\,S\,cm^{-1}$ at 700 °C is achieved in wet hydrogen (3% H_2O), the value of which is comparable with the state-of-the-art proton conductor $BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$ (BZCY). The peak power density achieves $505\,mW\,cm^{-2}$ at 700 °C with a 30-μm-thick BCS–SDC electrolyte using wet H_2 as the fuel. Resistances of the tested cell under open circuit conditions at different operating temperatures are also investigated by impedance spectroscopy.

11/02923 Application of response surface methodology to optimize and investigate the effects of operating conditions on the performance of DMFC

Taymaz, I. *et al. Energy*, 2011, 36, (2), 1155–1160.

In this study, the response surface methodology has been applied to optimize the operating conditions of direct methanol fuel cell (DMFC). A quadratic model was developed through RSM in terms of related independent variable to describe the current as the response. The input data required in this model has been obtained experimentally. For this purpose, an experimental set up for testing of DMFC has been established to investigate the effects of temperature and flow rate parameters on the cell performance. Two different analyses for operating conditions were performed applying the response surface method to obtain the maximum power. These analyses were based on the unlimited and minimum methanol consumptions. Methanol flow rate, oxygen flow rate, methanol temperature, humidification temperature and cell temperature were the main parameters considered that they were varied between 2 and 50 ml/min, 100–1000 ml/min, 30–70 °C, 30–70 °C and 30–80 °C in the analyses, respectively. The maximum current under the unlimited and minimum methanol consumptions was found as 1230 mA and 582 mA based on the contour plots and variance analysis.

11/02924 Competitiveness of CO_2 capture from an industrial solid oxide fuel cell combined heat and power system in the early stage of market introduction

Kuramochi, T. *et al. Fuel*, 2011, 90, (3), 958–973.

In this article, it was investigated whether potentially low-cost CO_2 capture from SOFC systems could enhance the penetration of SOFC in the energy market in a highly carbon-constrained society in the mid-term future (up to 2025). The application of 5 MWe SOFC systems for industrial combined heat and power (CHP) generation was considered. For CO_2 capture, oxyfuel combustion of anode off-gas using commercially available technologies was selected. A gas turbine (GT)-CHP plant was considered to be the reference case. Technical results showed that despite the energy penalties due to CO_2 capture and compression, net electrical and heat efficiencies were nearly identical with or without CO_2 capture. This was due to higher heat recovery efficiency by separating SOFC off-gas streams for CO_2 capture. However, CO_2 capture significantly increased the required SOFC and heat exchanger areas. Economic results showed that for above 40–50 $\$\,t^{-1}$ CO_2 price, SOFC-CHP systems were more economical when equipped with CO_2 capture. CO_2 capture also enabled SOFC-CHP to compete with GT-CHP at higher cell stack production costs. At zero CO_2 price, cell stack production cost had to be as low as 140 kW^{-1} for SOFC-CHP to outperform GT-CHP. At 100 $\$\,t^{-1}$ CO_2 price, the cell stack production cost requirement raised to 350 $\$\,kW^{-1}$. With CO_2 capture, SOFC-CHP still outperformed GT-CHP at a significantly higher cell stack production cost above 900 $\$\,kW^{-1}$.

11/02925 Design and modeling of power system for a fuel cell hybrid switcher locomotive

Guo, L. *et al. Energy Conversion and Management*, 2011, 52, (2), 1406–1413.

This paper discusses the design and modelling of power system for a fuel cell hybrid locomotive. Different types of fuel cells for appropriate application to locomotives were compared, fuel cell and auxiliary storage devices were modelled, and a control strategy for the overall system was developed in this paper. By using the proposed control strategy, the power control system regulates the sharing of power demand between fuel cell and auxiliary storage units including batteries and ultracapacitors. Experimental data of the power duty cycle of a typical switcher locomotive is analysed. The proposed control system is tested using the experimental data. Results show that the control system is able to maintain output voltage from different power sources within a certain range, keep the state of charge of the batteries within an optimal range and meet power demand of the locomotive at a high efficiency.

11/02926 Effect of contaminants on polymer electrolyte membrane fuel cells

Zamel, N. and Li, X. *Progress in Energy and Combustion Science*, 2011, 37, (3), 292–329.

Increasing demand for energy, energy security and the need to minimize the impact on the environment related to energy are the major drivers for the research and development of alternative energy technologies. Polymer electrolyte membrane (PEM) fuel cells are a promising alternative technology. However, their performance, in other words efficiency, can be hindered severely by the presence of contaminants. Impurities in the oxidant and fuel feeds act as barriers to the oxygen reduction and hydrogen oxidation. These impurities arise from the use of atmospheric air as the oxidant and hydrogen from reformate as the fuel. The electrolyte membrane can be attacked by ions originating from the cell components. These ions decrease the mechanical and chemical stability of the membrane resulting in the decrease of proton conductivity and reactant crossover. Due to the severity of these poisoning phenomena, much work has been dedicated to understanding their chemical kinetics, their effects and mitigation methods. This paper provides a comprehensive review of the experimental, analytical and numerical work devoted to understanding the contamination of the cathode, electrolyte membrane and anode. A summary of future directions and research topics is also given.

11/02927 Effect of pressure drop in different flow fields on water accumulation and current distribution for a micro PEM fuel cell

Hsieh, S.-S. *et al. Energy Conversion and Management*, 2011, 52, (2), 975–982.

Time-dependent measurements of pressure drop in different flow fields on the cathode of a PEM fuel cell with different operating conditions of mass flow rates and cell temperatures on current distribution were conducted. The results show that, among four flow fields studied herein, the interdigitated flow channel has the biggest pressure drop and least influence on current distribution at an early phase ($\leq$30 min) compared to those of the other three channels. In addition, the effect of pressure drop on water accumulation was noted. Similarly, the effects of mass flow rates as well as the cell temperature were also examined and discussed.

11/02928 Effects of gas recycle on performance of solid oxide fuel cell power systems

Jia, J. *et al. Energy*, 2011, 36, (2), 1068–1075.

An energy analysis of solid oxide fuel cell (SOFC) power systems with gas recycles fed by natural gas is carried out. Simple SOFC system, SOFC power systems with anode and cathode gas recycle respectively and SOFC power system with both anode and cathode gas recycle are compared. Influences of reforming rate, air ratio and recycle ratio of electrode exhaust gas on performance of SOFC power systems are investigated. Net system electric efficiency and cogeneration efficiency of these power systems are given by a calculation model. Results show that internal reforming SOFC power system can achieve an electrical efficiency of more than 44% and a system cogeneration efficiency including waste heat recovery of 68%. For SOFC power system with anode gas recycle, an electrical efficiency is above 46% and a cogeneration efficiency of 88% is obtained. In the case of cathode gas recycle, an electrical efficiency and a cogeneration efficiency is more than 51% and 78%, respectively. Although SOFC system with both anode and cathode gas is more complicated, the electrical efficiency of it is close to 52%.

11/02929 Experimental analysis of a two-material active magnetic regenerator

Arnold, D. S. *et al. International Journal of Refrigeration*, 2011, 34, (1), 178–191.

Experimental results of an active magnetic regenerator (AMR) composed of two equal volumes of gadolinium and $Gd_{0.85}Er_{0.15}$ using $2T$ and $5T$ are reported. Drive forces and system losses are measured as a function of thermal load and magnetic field. Metrics for coefficient of performance and efficiency are defined and used to distinguish between regenerator and device performance. Results suggest the largest temperature spans are expected to occur when each material is operating with its average temperature near their Curie temperatures. Force measurements indicate that mechanical losses and pumping power are the most significant contributions to network while the net magnetic work is too small to be resolved. COP values for the magnetic cycle are as high as 2.4 while efficiencies are all less than 0.15. A maximum exergetic cooling of 1.94 W is estimated with a corresponding specific exergetic cooling power of 23 $W\,T^{-1}L^{-1}$.

11/02930 Experimental study of commercial size proton exchange membrane fuel cell performance

Yan, W.-M. *et al. Applied Energy*, 2011, 88, (1), 392–396.

Commercial-sized ($16 \times 16\,cm^2$ active surface area) proton exchange membrane (PEM) fuel cells with serpentine flow chambers are fabricated. The GORE-TEX® PRIMEA 5621 was used with a 35-μm-thick PEM with an anode catalyst layer with 0.45 $mg\,cm^{-2}$ Pt and cathode catalyst layer with 0.6 $mg\,cm^{-2}$ Pt and Ru or GORE-TEX® PRIMEA 57 was used with an 18-μm-thick PEM with an anode catalyst layer at 0.2 $mg\,cm^{-2}$ Pt and cathode catalyst layer at 0.4 $mg\,cm^{-2}$ of Pt and Ru. At the specified cell and humidification temperatures, the thin PRIMEA 57 membrane yields better cell performance than the thick PRIMEA 5621 membrane, since hydration of the former is more easily maintained with the limited amount of produced water. Sufficient humidification at both the cathode and anode sides is essential to achieve high cell performance with a thick membrane, like the PRIMEA 5621. The optimal cell temperature to produce the best cell performance with PRIMEA 5621 is close to the humidification temperature. For PRIMEA 57, however, optimal cell temperature exceeds the humidification temperature.

11/02931 Fuel cell vehicles: state of the art with economic and environmental concerns

Veziroglu, A. and Macario, R. *International Journal of Hydrogen Energy*, 2011, 36, (1), 25–43.

Hydrogen-fuelled fuel-cell vehicles (FCVs) will play a major role as a part of the change toward the hydrogen-based energy system. When combined with the correct source of energy, fuel cells have the highest potential efficiencies and lowest potential emissions of any vehicular power source. As a result, extensive work into the development of hydrogen-fuelled FCVs is taking place. The aim of this paper is to highlight some of the research and development work which has occurred in the past 5 years on fuel-cell vehicle technology, with a focus on economic and environmental concerns. It is observed that the current efforts are divided up into several parts. The performance, durability, and cost of fuel-cell technology continue to be improved, and some fuel cells are currently ready to be mounted on vehicles and tested. Environmental and economic assessments of the entire hydrogen supply chain, including fuel cell end-use, are being carried out by groups of researchers around the world. It is currently believed that fuel cells need at least an additional 5 years of testing and improvement before large-scale commercialization can begin. Economic and environmental analyses show that FCVs will likely be both economically competitive and environmentally benign. Indeed, the transition of the transportation sector to the use of hydrogen FCVs will represent one of the biggest steps toward the hydrogen economy.

11/02932 Glycerol oxidation in solid oxide fuel cells based on a Ni-perovskite electrocatalyst

Lo Faro, M. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1075–1084.
An investigation of the electrochemical oxidation of glycerol as alternative to hydrogen and methane in solid oxide fuel cells (SOFCs) based on a noble metal-free anode catalyst was carried out. The anode electrocatalyst consisted of a Ni-modified $La_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_3$ (LSFCO) perovskite. After thermal activation, air treatment at 1100 °C followed by reduction at 800 °C in H_2, Ni was mainly present as ultrafine La_2NiO_4 particles homogeneously dispersed on the perovskite surface. The thermal activation also caused a modification of perovskite into a lanthanum depleted structure. The thermal reduction at 800 °C determined the occurrence of metallic Ni on the surface. These results were corroborated by X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM) and X-ray diffraction (XRD). A suitable power density ($327\,mW\,cm^{-2}$) was achieved for the electrolyte supported SOFC fed with chemical-grade glycerol in almost dry condition, i.e. steam to carbon ratio (S/C) of 0.2. The highest electrical efficiency (voltage efficiency) approached 50% at the peak power under mild humidification ($S/C = 0.2$). Whereas an increase of water to glycerol ratio, caused a progressive decrease of voltage efficiency at the peak power down to 44% for $S/C = 2$.

11/02933 In situ diagnostics for water transport in proton exchange membrane fuel cells

Tsushima, S. and Hirai, H. *Progress in Energy and Combustion Science*, 2011, 37, (2), 204–220.
Proton exchange membrane fuel cells (PEMFCs) have attracted considerable attention as energy-conversion systems for future applications in vehicles and for on-site power generation. Major technical challenges exist in achieving a high cell performance over a wide range of operating conditions, such as various cell current densities, operating temperatures, and relative humidities of the supplied gases. Correct water management is critical to achieving a high power density, long-term operation, and increased robustness in PEMFCs. Aspects such as the swelling of the membrane by water, the generation and accumulation of liquid water inside the fuel cells, and the discharge of accumulated water need to be clarified to ensure a fundamental understanding of water transport in PEMFCs. This paper examines the state of art regarding *in situ* diagnostics, particularly visualization techniques, for probing the behaviour of water in PEMFCs, with attention to neutron radiography, X-ray imaging, magnetic resonance imaging, and optical visualization techniques. The recent rapid development of *in situ* imaging techniques with high spatial and temporal resolutions provides a novel platform for the development of PEMFCs.

11/02934 Investigations on gas-phase reactions of ethane under SOFC conditions: an experimental and modeling study

Huang, X. and Reimert, R. *Fuel*, 2011, 90, (2), 689–694.
Experiments using a model gas mixture which is chosen to represent hydrocarbon fuel from hydrothermal gasification of biomass were carried out under gas-phase conditions similar to those expected in the anode channel of a solid-oxide fuel cell (SOFC). Ethane conversion and product formation were evaluated from the measurements at various temperatures ranging from 610 to 860 °C and at a total pressure of 1.2 bar. The employed reactor was simulated using a plug-flow model coupled to a detailed gas-phase reaction mechanism. The measured temperature profile along the reactor was imported in the calculation routine. A satisfying agreement in both ethane conversion and product composition was reached between the model predictions and the experimental data. In order to determine which reactions were responsible for much of the observed kinetics a sensitivity analysis based on the rate of production (ROP) principle was performed. The results from the sensitivity analysis show that there are only six elementary reactions whose rates significantly affect the consumption or formation of the four species of interest, i.e. H_2, CH_4, C_2H_4 and C_2H_6.

11/02935 Modeling and off-design performance of a 1 kW_e HT-PEMFC (high temperature-proton exchange membrane fuel cell)-based residential micro-CHP (combined-heat-and-power) system for Danish single-family households

Arsalis, A. *et al. Energy*, 2011, 36, (2), 993–1002.
A novel proposal for the modelling and operation of a micro-CHP (combined-heat-and-power) residential system based on HT-PEMFC (high temperature-proton exchange membrane fuel cell) technology is described and analysed to investigate its commercialization prospects. An HT-PEMFC operates at elevated temperatures, as compared to Nafion-based PEMFCs and therefore can be a significant candidate for cogeneration residential systems. The proposed system can provide electric power, hot water, and space heating for a typical Danish single-family household. A complete fuel processing subsystem, with all necessary BOP (balance-of-plant) components, is modelled and coupled to the fuel cell stack subsystem. The micro-CHP system is simulated in LabVIEW environment to provide the ability of data acquisition of actual components and thereby more realistic design in the future. A part-load study has been conducted to indicate performance characteristics at off-design conditions. The system is sized to provide realistic dimensioning of the actual system.

11/02936 Non-isothermal transport phenomenon and cell performance of a cathodic PEM fuel cell with a baffle plate in a tapered channel

Perng, S.-H. and Wu, H.-W. *Applied Energy*, 2011, 88, (1), 52–67.
This study uses a projection finite element analysis with an element-by-element preconditioned conjugate gradient method to investigate the non-isothermal tapered flow channel installed with a baffle plate for enhancing cell performance in the cathodic side of a proton exchange membrane fuel cell. The parameters studies including tapered ratio (0.25–1.0) and gap ratio (0.005–0.2) on the cell performance have been explored in detail. The results indicate that the stronger composite effect of tapered flow channel and baffle blockage provides a better convection heat transfer performance and a higher fuel flow velocity and thus enhances the cell performance.

11/02937 Numerical study of on-board fuel reforming in a catalytic plate reactor for solid-oxide fuel cells

Janardhanan, V. M. *et al. Chemical Engineering Science*, 2011, 66, (3), 490–498.
A pseudo-transient numerical model was used for the simulation of a multi-functional catalytic plate reactor (CPR). The work mainly addresses the problems associated with on-board reforming for solid-oxide fuel cells. Heat management is achieved by indirectly coupling partial oxidation with reforming. Water management is achieved by partially recycling the anode stream from a solid-oxide fuel cell. The model uses detailed heterogeneous chemistry for reforming and oxidation reactions occurring on the catalyst beds.

11/02938 Perfluorosulfonic acid-functionalized Pt/carbon nanotube catalysts with enhanced stability and performance for use in proton exchange membrane fuel cells

He, D. *et al. Carbon*, 2011, 49, (1), 82–88.
To further improve lifetime and performance of carbon nanotube (CNT) supported Pt catalysts for proton exchange membrane fuel cells, perfluorosulfonic acid (PFSA) was introduced by a simple colloid route to functionalize Pt (PFSA-Pt/CNT) catalysts. Here the PFSA is available as a binder to tightly anchor Pt nano-particles onto the CNT surfaces, and as a proton conductor to increase the triple phase boundary zone of the catalysts. The prepared Pt nano-particles ranging from 2 to 5 nm in diameter are uniformly deposited on CNTs. A high catalytic activity of this novel composite catalyst was observed by both cyclic voltammetry and oxygen reduction reaction (ORR) measurements. The loss rate of the electrochemically active area of the PFSA-Pt/CNT catalyst decreases by a factor of two in comparison with that of the plain Pt/CNT catalyst. Meanwhile, a lower loss rate for the new catalyst was also observed by electrochemically-accelerated durability testing for the ORR activity. These results indicate that the stability of the new catalyst is significantly improved over that of the plain Pt/CNT catalyst by introduction of PFSA.

11/02939 PtRuP nanoparticles supported on mesoporous carbon thin film as highly active anode materials for direct methanol fuel cell

Lin, M.-L. *et al. Catalysis Today*, 2011, 160, (1), 109–115.
PtRu nanocatalyst supported on mesoporous carbon thin film (TFC) with incorporation of the non-metallic phosphorus is explored as an anodic catalytic material for direct methanol fuel cell (DMFC). The catalyst 20 wt% $PtRuP_{0.1}$/TFC gives a very high current density in the electrochemical oxidation of methanol, which is much enhanced than that of the PtRu/TFC without P loading and two times higher compared to a commercial PtRu/XC-72 catalyst. XPS and EXAFS analysis of the catalysts show that phosphorus helps to reduce the size of PtRu nanoalloy by acting as a surface protecting agent to the nanoparticles and it does not alter the electronic structure of PtRu. The PtRuP nanocatalyst with a particle size of 3 nm was found to have the best reactivity and catalytic stability.

11/02940 Seeker optimization algorithm for global optimization: a case study on optimal modelling of proton exchange membrane fuel cell (PEMFC)

Dai, C. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 369–376.

In order to optimize the proton exchange membrane fuel cell (PEMFC) model parameters, a novel approach based on seeker optimization algorithm (SOA) is proposed. The SOA is based on the concept of simulating human searching behaviours, where the choice of search direction is based on the empirical gradient by evaluating the response to the position changes and the decision of step length is based on uncertainty reasoning by using a simple fuzzy rule. In this study, after evaluated on benchmark function optimization, the SOA is applied to optimal modelling of the PEMFC by using a fuel cell test system in Fuel Cell Application Centre at the Temasek Polytechnic, and compared with several state-of-the-art versions of differential evolution (DE) and particle swarm optimization (PSO) algorithms. The simulation results show that the proposed approach is superior to other compared algorithms, and the PEMFC model with optimized parameters by SOA fitted experimental data well. Hence, SOA is an effective and reliable technique for optimizing the parameters of PEMFC model, and can be helpful for system analysis, optimization design and real-time control of the PEMFCs.

11/02941 Simultaneous degradation of refractory contaminants in both the anode and cathode chambers of the microbial fuel cell

Luo, Y. *et al. Bioresource Technology*, 2011, 102, (4), 3827–3832.

In this study, the microbial fuel cell (MFC) was combined with the Fenton-like technology to simultaneously generate electricity and degrade refractory contaminants in both anode and cathode chambers. The maximum power density achieved was 15.9 W/m^3 at an initial pH of 3.0 in the MFC. In the anode chamber, approximately 100% of furfural and 96% COD were removed at the end of a cycle. In the cathode chamber, the Fenton-like reaction with $FeVO_4$ as a catalyst enhanced the removal of AO7 and COD. The removal rates of AO7 and COD reached 89% and 81%, respectively. The optimal pH value and $FeVO_4$ dosage toward degrading AO7 were about 3.0 and 0.8 g, respectively. Furthermore, a two-way catalyst mechanism of $FeVO_4$ and the contaminant degradation pathway in the MFC were explored.

11/02942 Study on a compact methanol reformer for a miniature fuel cell

Pan, L. *et al. International Journal of Hydrogen Energy*, 2011, 36, (1), 319–325.

A compact methanol reformer for hydrogen production has been successfully fabricated, which integrated one reforming chamber, one water gas shift reaction chamber, two preheating chambers and two combustion chambers. It can be started-up at room temperature by the combustion of liquid methanol in the combustion chamber within 7 min without any external heating. The cold start response of the methanol reformer has been investigated using different parameters including methanol and air supply rate, and the experiments revealed that the optimum methanol and air flow rate were 0.55 and 3 L/min, respectively. The results indicated that this methanol reformer can provide a high concentration of hydrogen (more than 73%) and the system efficiency is always maintained above 74%. It is further demonstrated in more than 1600 h continuous performance that the reformer could be operated autothermally and exhibited good test stability.

11/02943 Water transport in polymer electrolyte membrane fuel cells

Jiao, K. and Li, X. *Progress in Energy and Combustion Science*, 2011, 37, (3), 221–291.

Polymer electrolyte membrane fuel cell (PEMFC) has been recognized as a promising zero-emission power source for portable, mobile and stationary applications. To simultaneously ensure high membrane proton conductivity and sufficient reactant delivery to reaction sites, water management has become one of the most important issues for PEMFC commercialization, and proper water management requires good understanding of water transport in different components of PEMFC. In this paper, previous researches related to water transport in PEMFC are comprehensively reviewed. The state and transport mechanism of water in different components are elaborated in detail. Based on the literature review, it is found that experimental techniques have been developed to predict distributions of water, gas species, temperature and other parameters in PEMFC. However, difficulties still remain for simultaneous measurements of multiple parameters, and the cell and system design modifications required by measurements need to be minimized. Previous modelling work on water transport in PEMFC involves developing rule-based and first-principle-based models, and first-principle-based models involve multi-scale methods from atomistic to full cell levels. Different models have been adopted for different purposes and they all together can provide a comprehensive view of water transport in PEMFC. With the development of computational power, application of lower length scale methods to higher length scales for more accurate and comprehensive results is feasible in the future. Researches related to cold start (startup from subzero temperatures) and high temperature PEMFC (HT-PEMFC) (operating at the temperatures higher than 100 °C) are also reviewed. Ice formation that hinders reactant delivery and damages cell materials is the major issue for PEMFC cold start, and enhancing water absorption by membrane electrolyte and external heating have been identified as the most effective ways to reduce ice formation and accelerate temperature increment. HT-PEMFC that can operate without liquid water formation and membrane hydration greatly simplifies water management strategy, and promising performance of HT-PEMFC has been demonstrated.

15 ENVIRONMENT

Pollution, health protection, applications

11/02944 100% Renewable energy systems, climate mitigation and economic growth

Vad Mathiesen, B. *et al. Applied Energy*, 2011, 88, (2), 488–501.

Greenhouse gas mitigation strategies are generally considered costly with world leaders often engaging in debate concerning the costs of mitigation and the distribution of these costs between different countries. In this paper, the analyses and results of the design of a 100% renewable energy system by the year 2050 are presented for a complete energy system including transport. Two short-term transition target years in the process towards this goal are analysed for 2015 and 2030. The energy systems are analysed and designed with hour-by-hour energy system analyses. The analyses reveal that implementing energy savings, renewable energy and more efficient conversion technologies can have positive socio-economic effects, create employment and potentially lead to large earnings on exports. If externalities such as health effects are included, even more benefits can be expected. One hundred per cent renewable energy systems will be technically possible in the future, and may even be economically beneficial compared to the business-as-usual energy system. Hence, the current debate between leaders should reflect a combination of these two main challenges.

11/02945 A relation between calculated human body exergy consumption rate and subjectively assessed thermal sensation

Simone, A. *et al. Energy and Buildings*, 2011, 43, (1), 1–9.

Application of the exergy concept to research on the built environment is a relatively new approach. It helps to optimize climate conditioning systems so that they meet the requirements of sustainable building design. As the building should provide a healthy and comfortable environment for its occupants, it is reasonable to consider both the exergy flows in building and those within the human body. Until now, no data have been available on the relation between human-body exergy consumption rates and subjectively assessed thermal sensation. The objective of the present work was to relate thermal sensation data, from earlier thermal comfort studies, to calculated human-body exergy consumption rates. The results show that the minimum human body exergy consumption rate is associated with thermal sensation votes close to thermal neutrality, tending to the slightly cool side of thermal sensation. Generally, the relationship between air temperature and the exergy consumption rate, as a first approximation, shows an increasing trend. Taking account of both convective and radiative heat exchange between the human body and the surrounding environment by using the calculated operative temperature, exergy consumption rates increase as the operative temperature increases above 24 °C or decreases below 22 °C. With the data available so far, a second-order polynomial relationship between thermal sensation and the exergy consumption rate was established.

11/02946 Agricultural policy and its impact on fuel usage: empirical evidence from farm household analysis

Chang, H.-H. *et al. Applied Energy*, 2011, 88, (1), 348–353.

Off-farm work is a growing reality in the US agricultural sector as a whole. Another staple program in the US agriculture is the use of crop insurance. This paper assesses hitherto unaddressed issues of fuel consumption and hence pollution generated by farm households associated with off-farm work and crop insurance. A quantile regression method was applied to unique national farm-level survey data to address the fuel consumption issues. Results indicate that off-farm work by operators tends to decrease fuel expenses. In contrast, households with crop insurance had higher fuel consumption thereby increasing fuel usage. Finally, the study shows that the net effect of these two activities resulted in an increase in the pollution level.

11/02947 Air fuelled zero emission road transportation: a comparative study

Chen, H. *et al. Applied Energy*, 2011, 88, (1), 337–342.

Road transportation using air as a fuel has attracted much attention over the past decade. The fuel (air) can be in two forms, compressed gas form and cryogenic liquid form and engines based on both forms of air have been investigated. Prototypes of air-powered road vehicles are expected to emerge over the next few years. However, there have been debates over the advantages and disadvantages of the two technologies. This paper aims to compare the two technologies from the technological point of view. Engines for a typical small-scale passenger car are used for the analyses and the comparison is based on the shaft work, coolth, efficiency and energy density. It is shown that the shaft work outputs and the coolth available to engines powered by both fuels increase with increasing working pressure and temperature. Given the working pressure and temperature, liquid-air-powered engines have a slightly lower specific work outputs than compressed-air-powered engines. The volumetric energy density of liquid air, however, is much higher than that of compressed air, and liquid air has much higher coolth than compressed air. On the other hand, the efficiency of the compressed-air-powered engines is higher than that of liquid-air-powered engines mainly because of the higher energy consumption of liquefaction plants. The analyses also suggest that an effective use of coolth be a key to improve the overall efficiency of liquid-air-powered engines.

11/02948 Analysis on the characteristics of a pollutant dispersion in river environment

Kim, K.-C. *et al. Annals of Nuclear Energy*, 2011, 38, (2–3), 232–237.

A tracer experiment using a radioisotope was carried out to investigate the characteristics of pollutant transport and to estimate the dispersion coefficients in a river system. A well-known radioisotope tracer technique was applied to measure the dispersion coefficients in Daejong river which is located in the south-east area in Korea. The dispersion coefficients were determined by moment, routing and analytical methods based on the measured radioisotope data. Two-dimensional numerical models were used to simulate the flow fields and the concentration distributions of the radioisotope injected into the river. The calculated results were compared with the measurements. As a comparative study, the computed concentration distributions agreed well in the case of the usage of the dispersion coefficients determined by the moment method.

11/02949 Assessing the effect of oil price on world food prices: application of principal component analysis

Esmaeili, A. and Shokoohi, Z. *Energy Policy*, 2011, 39, (2), 1022–1025.

This study examined the food prices of seven major products: eggs, meat, milk, oilseeds, rice, sugar and wheat. The macroeconomic variables studied were crude oil prices, consumer price indexes, food production indexes and GDP around the world between 1961 and 2005. The Scree test and the proportion of variance method were used for determining the optimal number of common factors. The correlation coefficient between the extracted principal component and the macroeconomic index varies between 0.87 for the world GDP and 0.36 for the consumer price index. It was found that the food production index has the greatest influence on the macroeconomic index and that the oil price index has an influence on the food production index. Consequently, crude oil prices have an indirect effect on food prices.

11/02950 Characteristics of vegetation and its relationship with landfill gas in closed landfill

Chai, X. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1295–1301.

An investigation was carried out to elucidate landfill gas and the vegetation characteristics in closed landfill. The results indicate that the stabilization process of the landfill is an important factor influencing the components of landfill gases. The coverage, height and species of vegetation increase with the closed time of landfill. Fourteen species were observed in the investigated cells, dominated by *Phragmites australis*, an invasive perennial plant. The concentrations of methane and carbon dioxide from vegetated cover soil were lower than those from non-vegetated cover soil.

11/02951 Climate change, nuclear power, and the adaptation–mitigation dilemma

Kopytko, N. and Perkins, J. *Energy Policy*, 2011, 39, (1), 318–333.

Many policy-makers view nuclear power as a mitigation for climate change. Efforts to mitigate and adapt to climate change, however, interact with existing and new nuclear power plants, and these installations must contend with dilemmas between adaptation and mitigation. This paper develops five criteria to assess the adaptation–mitigation dilemma on two major points: (1) the ability of nuclear power to adapt to climate change and (2) the potential for nuclear power operation to hinder climate change adaptation. Sea level rise models for nine coastal sites in the USA, a review of US Nuclear Regulatory Commission documents, and reports from France's nuclear regulatory agency provided insights into issues that have arisen from sea level rise, shoreline erosion, coastal storms, floods, and heat waves. Applying the criteria to inland and coastal nuclear power plants reveals several weaknesses. Safety stands out as the primary concern at coastal locations, while inland locations encounter greater problems with interrupted operation. Adapting nuclear power to climate change entails either increased expenses for construction and operation or incurs significant costs to the environment and public health and welfare. Mere absence of greenhouse gas emissions is not sufficient to assess nuclear power as a mitigation for climate change.

11/02952 Differing forms, differing purposes: a typology of health impact assessment

Harris-Roxas, B. and Harris, E. *Environmental Impact Assessment Review*, 2011, 31, (4), 396–403.

There is currently considerable diversity in health impact assessment (HIA) practice internationally. Historically this diversity has been described as simple dichotomies, for example the differences between HIAs of projects and policies. However these distinctions have failed to adequately describe the differences that can be observed between different forms of HIAs. This paper describes the three historical and disciplinary fields from which HIA has emerged: environmental health, a social view of health, and health equity. It also puts forward a typology of four different forms of HIA that can be observed in current HIA practice: mandated, decision-support, advocacy, and community-led HIAs. This paper argues that these different forms of HIA serve different purposes and are not necessarily in competition; rather they allow HIA to be responsive to a range of population health concerns and purposes.

11/02953 Effectiveness of daylighting design and occupant visual satisfaction in a LEED gold laboratory building

Hua, Y. *et al. Building and Environment*, 2011, 46, (1), 54–64.

Using daylight as primary light source has been widely recognized as an important strategy to reduce building energy demand and enhance indoor environment quality. However, to design and operate a building to make full use of daylight, which is a dynamic light source, to meet diverse occupant needs remains a challenge. This paper reports a post-occupancy study of the visual environment in a laboratory building on a university campus, and puts a spotlight on the building occupants as it examines the effectiveness of the daylighting design and systems integration in creating a visual environment to support occupant comfort and satisfaction while reducing artificial lighting demand. Results show generally high satisfaction with daylit work environment and positive effect of the horizontal shading strategy. Issues about the integration between daylighting and electric lighting systems and level of occupant control are identified and discussed for improving the effectiveness of daylighting and enhancing the quality of the visual environment in the building of study. A multiple-tool methodology is developed and tested, which included occupant surveys, interviews, illuminance measurements, continuous data loggers, fisheye-lens camera and glare-identifying software, and documentation of spatial settings, systems features, and user behaviour.

11/02954 Electoral competition with environmental policy as a second best transfer

Kawahara, S. *Resource and Energy Economics*, 2011, 33, (3), 477–495.

This paper explains why some governments fail to adopt policies that are sufficiently strong, while others adopt policies that are too stringent. Constructing a political economy model in which voters face uncertainty due to the types of politicians and the risk of environmental damage, the authors show that there is an equilibrium in which a politician uses a weaker environmental policy rather than efficient direct transfers for redistribution. They also show that there is an equilibrium in which a stricter environmental policy can be implemented by a politician who has no incentive to make transfers. Then, the authors discuss which equilibrium should be more plausible. They conclude that the latter equilibrium in which a too stringent environmental policy emerges can dominate the former unless the citizen's estimate of environmental risk is sufficiently low.

11/02955 Energy literacy of secondary students in New York State (USA): a measure of knowledge, affect, and behavior

DeWaters, J. E. and Powers, S. E. *Energy Policy*, 2011, 39, (3), 1699–1710.

Energy literacy, which encompasses broad content knowledge as well as affective and behavioural characteristics, will empower people to make appropriate energy-related choices and embrace changes in the way we harness and consume energy. Energy literacy was measured with a written questionnaire completed by 3708 secondary students in New York state, USA. Results indicate that students are concerned about energy problems (affective subscale mean 73% of the maximum attainable score), yet relatively low cognitive (42% correct) and behavioural (65% of the maximum) scores suggest that students may lack the knowledge and skills they need to effectively contribute toward solutions. High school (HS) students scored significantly better than middle school (MS) students on the cognitive subscale; gains were greatest on topics included in New York state educational standards, and less on topics related to 'practical' energy knowledge such as ways to save energy. Despite knowledge gains, there was a significant drop in energy conservation behaviour between the MS and HS students. Intercorrelations between groups of questions indicate energy-related behaviours are more strongly related to affect than to knowledge. These findings underscore the need for education that improves energy literacy by impacting student attitudes, values and behaviors, as well as broad content knowledge.

11/02956 Experimental study of hydronic panels system and its environment

Díaz, M. F. *Energy Conversion and Management*, 2011, 52, (1), 770–780.

An experimental analysis of hydronic cooling or heating ceiling panels coupled to the building is present in this investigation as a part of the commissioning study of this system. Two test chambers are adapted in a way to reproduce the interaction of the system to the building (windows, internal thermal loads distribution, building structure and ventilation). A series of experimental tests were performed in which the main objective is to observe the influence of parameters such as the water mass flow rate, supply water temperature, thermal load distribution, window and ventilation system effects on the hydronic ceiling capacity and comfort conditions. Test results show that the influence of asymmetric surfaces temperatures inside the room, especially the window effect is not negligible. Then, it is clear that the cooling hydronic ceiling must be evaluated coupled to the building systems and structure.

11/02957 Explaining the differential distribution of clean development mechanism projects across host countries

Winkelman, A. G. and Moore, M. R. *Energy Policy*, 2011, 39, (3), 1132–1143.

The clean development mechanism (CDM) of the Kyoto Protocol represents an opportunity to involve all developing countries in the effort to reduce greenhouse gas emissions while also promoting sustainable development. To date, however, the majority of CDM projects have gone to emerging markets such as China, India, Brazil, and Mexico, while very few least developed countries have hosted projects. This paper investigates the differential distribution of CDM activities across countries. The authors develop a conceptual model for project profitability, which helps to identify potential country-level determinants of CDM activity. These potential determinants are employed as explanatory variables in regression analysis to explain the actual distribution of projects. Human capital and greenhouse gas emission levels influenced which countries have hosted projects and the amount of certified emission reductions (CER) created. Countries that offered growing markets for CDM co-products, such as electricity, were more likely to be CDM hosts, while economies with higher carbon intensity levels had greater CER production. These findings work against the least developed countries and help to explain their lack of CDM activity.

11/02958 Groundwater electrical conductivity and soil radon gas monitoring for earthquake precursory studies in Koyna, India

Reddy, D. V. and Nagabhushanam, P. *Applied Geochemistry*, 2011, 26, (5), 731–737.

Hourly monitoring of electrical conductivity (EC) of groundwater along with groundwater levels in the 210 m deep boreholes (specially drilled for pore pressure/earthquake studies) and soil Rn gas at 60 cm below ground level in real time, in the Koyna–Warna region (characterized by basaltic rocks, >1500 m thick, and dotted with several sets of fault systems), western India, provided strong precursory signatures in response to two earthquakes (M 4.7 on 14 November 2009, and M 5.1 on 12 December 2009) that occurred in the study region. The EC measured in Govare well water showed precursory perturbations about 40 h prior to the M 5.1 earthquake and continued further for about 20 h after the earthquake. In response to the M 4.7 earthquake, there were EC perturbations 8 days after the earthquake. In another well (Koyna) which is located 4 km north of Govare well, no precursory signatures were found for the M 4.7 earthquake, while for M 5.1 earthquake, post-seismic precursors were found 18 days after the earthquake. Increased porosity and reduced pressure head accompanied by mixing of a freshwater component from the top zone due to earthquakes are the suggested mechanisms responsible for the observed anomalies in EC. Another parameter, soil Rn gas showed relatively proportional strength signals corresponding to these two earthquakes. In both the cases, the pre-seismic increase in Rn concentration started about 20 days in advance. The co-seismic drop in Rn levels was less by 30% from its peak value for the M 4.7 earthquake and 50% for the M 5.1 earthquake. The Rn anomalies are attributed to the opening and closing of micro-fractures before and during the earthquake. On line monitoring of these two parameters may be useful to check the entire chemistry change due to earthquake which may help to forecast impending earthquakes.

11/02959 Health and impact assessment: are we seeing closer integration?

Morgan, R. K. *Environmental Impact Assessment Review*, 2011, 31, (4), 404–411.

Health has always had a place in wider impact assessment activities, from the earliest days of the National Environmental Policy Act in the USA. However, early thinking tended to focus on health protection and environmental health issues, especially in relation to the effects of pollution. The adoption of wider models of health was reflected in impact assessment circles from the early 1990s, with particular emphasis on an integrated approach to impact assessment, especially at the project level, which would see health impact assessment benefiting from working with other forms of impact assessment, such as social and ecological. Yet twenty years later, integration still seems a distant prospect in many countries. In this paper the author examines the case for integrating health considerations within the wider impact assessment process, discuss some of the problems that have historically restricted progress towards this end, and explore the degree to which impact assessment practitioners have been successful in seeking to improve the consideration of health in impact assessment. In New Zealand, project-level impact assessment is based on an integrated model under the Resource Management Act. In addition, HIA was recognized in the early 1990s as a valuable addition to the toolkit for project assessment. Since then policy-level HIA has grown supported by extensive capacity building. If health is being integrated into wider impact assessment, it should be happening in New Zealand where so many enabling conditions are met. Three major project proposals from New Zealand are examined, to characterize the broad trends in HIA development in New Zealand in the past 10 years and to assess the degree to which health concerns are being reflected in wider impact assessments. The findings are discussed in the context of the issues outlined in the early part of the paper.

11/02960 Human health-related externalities in energy system modelling the case of the Danish heat and power sector

Zvingilaite, E. *Applied Energy*, 2011, 88, (2), 535–544.

This paper discusses methodology of energy system modelling when reduction of local externalities, such as damage to the human health from energy production-related air pollution, is in focus. Ideally, the local energy externalities should be analysed by adopting the impact pathway approach of ExternE study, and following the pollutants from their release to the personal uptake and resulting health effects. This would require inclusion of air pollution modelling and monetary valuation of the impacts into an energy system optimization process. However, this approach involves a complex study and generalizations are needed. The way local externalities are included in the existing energy system models is identified and discussed in the paper. Only a few studies include localization aspects when internalizing local externalities in an energy system optimization. The performed analysis of the Danish heat and power sector verifies that it is cheaper for the society to include externalities in the planning of an energy system than to pay for the resulting damages later. Total health costs decrease by around 18% and total system costs decrease by nearly 4% when health externalities are included in the optimization. Furthermore, including localization aspects can reduce health costs of the heat and power sector in Denmark by additional 7%.

11/02961 Hybrid modeling of China's vehicle ownership and projection through 2050

Hao, H. *et al. Energy*, 2011, 36, (2), 1351–1361.

As representative for emerging vehicle market, China has one of the fastest growing rates of automobile ownership in the world. The huge and increasing vehicle stock has significantly contributed to the fast growing of China's energy demand and GHG emissions. It is an important issue to project China's vehicle ownership, which to a large extent determines China's oil demand and greenhouse gas emissions from road transportation sector in the future. This study established a hybrid model with three submodels to simulate the growth patterns of China's private passenger vehicles, urban public transport vehicles and economic utility vehicles. By using this model, China's vehicle population was projected to reach 184.8, 363.8 and 606.7 million by

2020, 2030 and 2050, respectively. The fast increase of urban private passenger vehicles is the main driving force for vehicle population growth. Population of urban private passenger vehicles would account for 70.1%, 81.1% and 86.1% of total vehicle population in 2020, 2030 and 2050, respectively. It was demonstrated by sensitivity analysis that vehicle population was quite sensitive to household income and vehicle price, implying an effective lever for regulating the growth of vehicle population.

11/02962 Impact of altitude on emission rates of ozone precursors from gasoline-driven light-duty commercial vehicles

Nagpure, A. S. *et al. Atmospheric Environment*, 2011, 45, (7), 1413–1417.

Vehicle emissions are major precursors for the formation of tropospheric ozone that can have adverse effect on human health, buildings and vegetation. The aim of this study is to investigate the impact of altitude on emission rates of ozone precursors (e.g. CO, NO_x and VOCs) from gasoline-driven light–duty commercial vehicles (LDCVs) in three Indian cities (Delhi, Dehradun, and Mussoorie). Basic equations of the international vehicle emission (IVE) model are applied to estimate emission rates from the LDCVs. Topography (altitude) and meteorology (temperature) specific parameters of the IVE model were modified to Indian conditions for estimating emission rates. Unlike NO_x, emission rates of CO and VOCs have increased with altitude. For example, CO emission rate has considerably increased from $36.5\,g\,km^{-1}$ in Delhi to $51.3\,g\,km^{-1}$ (i.e. by approximately 41%) in Mussoorie, whereas VOCs emission rate marginally increased from $3.2\,g\,km^{-1}$ to $3.6\,g\,km^{-1}$. Findings and their implications are important from human health perspective, especially for the people residing in high altitude cities where a peculiar combination of lower oxygen levels and high concentrations of CO and VOCs can adversely affect the public health. Also, increased levels of CO and VOCs at high altitudes may conspicuously influence the chemistry of tropospheric ozone.

11/02963 Indirect fuel use change (IFUC) and the lifecycle environmental impact of biofuel policies

Rajagopal, D. *et al. Energy Policy*, 2011, 39, (1), 228–233.

A common assumption in lifecycle assessment (LCA) based estimates of greenhouse gas (GHG) benefits (or costs) of renewable fuel such as biofuel is that it simply replaces an energy-equivalent amount of fossil fuel and that total fuel consumption remains unchanged. However, the adoption of renewable fuels will affect the price of fuel and therefore affect total fuel consumption which, may increase or decrease depending on the policy regime and market conditions. Using a representative two-region model of the global oil market in which, one region implements a domestic biofuel mandate and the other does not, the authors show that the net change in global fuel consumption due to the policy, which the authors term indirect fuel use change (IFUC), can have a significant impact on the net GHG emissions associated with biofuel. If LCA-based regulations are designed to account for indirect emissions such as indirect land use change, then the authors argue that IFUC emissions cannot be ignored. The work also shows how different policies can affect the environmental impact from adopting a given clean technology differently.

11/02964 Job retention in the British offshore sector through greening of the North Sea energy industry

Esteban, M. *et al. Energy Policy*, 2011, 39, (3), 1543–1551.

For the case of the UK there are currently three ways of obtaining energy from sea areas, namely from wind, tides and waves. A methodology was developed to determine the future size of the offshore renewable industry based on the concept of employment factor, or the number of people required to maintain each unit of electricity production. An assessment was made of the decline in the number of people employed in oil related jobs in the North Sea and the gap that this could create in the UK's economy unless this pool of offshore expertise could find an alternative employment in the renewable sector. The paper will also investigate the effect of gradually transforming the UK's oil and gas sector into offshore renewables. If this was to happen by 2050 the UK offshore renewable industry could produce between 127 and 146 TWh of electricity, equivalent to around 57–66% of the current energy consumption in the country.

11/02965 Making the connection: the relationship between fuel poverty, electricity disconnection, and prepayment metering

O'Sullivan, K. C. *et al. Energy Policy*, 2011, 39, (2), 733–741.

Fuel poverty, or inability to afford adequate heating for a reasonable outlay of expenditure, is a significant and under-researched problem in New Zealand. The connection between fuel poverty, and electricity disconnection or 'self-disconnection' is analysed for four cities using prepayment metering to pay for electricity. A price comparison analysis on a government-sponsored website showed that prepayment metering was more expensive than other payment options. This website analysis was supplemented by qualitative data from older people with chronic respiratory disease expressing their views about electricity disconnection and prepayment metering. Prepayment metering for electricity was found to be more expensive than other payment methods in New Zealand and older people's insights provided valuable context to these issues. Under the present payment schedule, the use of prepayment metering to pay for electricity is not a suitable policy instrument to address fuel poverty, which remains problematic. The deregulated electricity market continues to lead to increases in the real price of residential electricity and in the number of people in fuel poverty. The authors offer policy suggestions for reducing fuel poverty in New Zealand.

11/02966 Measured energy and water performance of an aspiring low energy/carbon affordable housing site in the UK

Gill, Z. M. *et al. Energy and Buildings*, 2011, 43, (1), 117–125.

This paper reviews the annual energy and water performance of an aspiring low energy/carbon affordable housing development in southern UK, comprising 25 houses heated by a biomass-fuelled district heating network. Electrical, heat and water consumption data was collected for all dwellings and more detailed data logging was conducted on a sample of four. The data were analysed to benchmark the overall site performance and compare the individual dwellings. The individual dwellings performed efficiently in terms of electricity, heat and water consumption. Significant variation was identified between maximum and minimum consumers, even when typical performance correlates (i.e. number of occupants, floor area) were accounted for. Water consumption varies by a factor of >7 and heat and electrical consumption by >3 which, given the homogeneous design and specification of the buildings, suggested that occupant behaviour was important. Site-wide energy consumption and losses (over and above individual dwelling use) reduced energy and carbon emissions performance by 85% and 70%, respectively. Although energy consumption in UK homes can be substantially reduced, the challenge for zero-carbon design is to address issues of total system performance, occupant behaviour and whole-building energy performance.

11/02967 Multi-stakeholder partnerships for transfer of environmentally sound technologies

Morsink, K. *et al. Energy Policy*, 2011, 39, (1), 1–5.

Multi-stakeholder partnerships can overcome many of the problems which exist with the transfer of environmentally sound technologies (ESTs) from developed to developing countries, but as yet they have not been explored in detail in the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). Technology transfer is an important part of the UNFCCC, but the mechanism for achieving this is problematic. Developed countries prefer a market approach whereas developing countries tend to negotiate for direct grants. Multi-stakeholder partnerships offer a pathway through which technology is transferred and developing country capacity enhanced, while the interests of developed country private enterprise innovators are also protected. The authors present opinions and a case-study on multi-stakeholder partnerships and discuss some of the advantages that multi-stakeholder partners can offer.

11/02968 Optimization of energy consumption and input costs for apple production in Iran using data envelopment analysis

Mousavi-Avval, S. H. *et al. Energy*, 2011, 36, (2), 909–916.

In this study a non-parametric method of data envelopment analysis (DEA) was applied to analyse the efficiency of farmers, discriminate efficient farmers from inefficient ones and to identify wasteful uses of energy in order to optimize the energy inputs for apple production in Tehran province, Iran. From this study the following results were obtained: from the total of 56 farmers, considered for the analysis, 34% and 54% were found to be technically and pure technically efficient, respectively. The technical, pure technical and scale efficiency scores of farmers were 0.7857, 0.8982 and 0.8666, respectively. Optimum energy requirement was found to be $37{,}993.15\,MJ\,ha^{-1}$; indicating that 11.29% of total energy input could be saved if the recommendations of this study are followed. From total energy saving, the contribution of electrical energy was the highest; it followed by chemicals energy inputs; implying that there was a great scope for saving energy inputs by improving the use pattern of these inputs. The results of economical analysis showed that the total costs of production could decreased from \$8227.70 to $\$7570.01\,ha^{-1}$; also the benefit to cost ratio and productivity improved from 1.24 to 1.34 and 2.52 to 2.74, respectively.

11/02969 Providing all global energy with wind, water, and solar power, Part II: reliability, system and transmission costs, and policies

Delucchi, M. A. and Jacobson, M. Z. *Energy Policy*, 2011, 39, (3), 1170–1190.

This is the second of two papers evaluating the feasibility of providing all energy for all purposes (electric power, transportation, and heating/cooling), everywhere in the world, from wind, water, and the sun (WWS). Part I described the prominent renewable energy plans that have been proposed and discussed the characteristics of WWS energy systems, the global demand for and availability of WWS energy, quantities and areas required for WWS infrastructure, and supplies of critical materials. Here, the authors discuss methods of addressing the variability of WWS energy to ensure that power supply reliably matches demand (including interconnecting geographically dispersed resources, using hydroelectricity, using demand-response management, storing electric power on site, over-sizing peak generation capacity and producing hydrogen with the excess, storing electric power in vehicle batteries, and forecasting weather to project energy supplies), the economics of WWS generation and transmission, the economics of WWS use in transportation, and policy measures needed to enhance the viability of a WWS system. The cost of energy today in a 100% WWS would be similar to the cost today. The authors conclude that barriers to a 100% conversion to WWS power worldwide are primarily social and political, not technological or even economic.

11/02970 R&D and abatement under environmental liability law: comparing incentives under strict liability and negligence if compensation differs from harm

Endres, A. and Friehe, T. *Energy Economics*, 2011, 33, (3), 419–425.

This paper analyses equilibrium research and design (R&D) in pollution control and equilibrium pollution abatement by polluters who are subject to environmental liability law when the level of compensation differs from the level of environmental harm. The authors contrast the performance of strict liability with that of the negligence rule. Privately optimal levels necessarily deviate from socially optimal ones under strict liability, whereas private decisions are first-best under negligence unless compensation is much smaller than harm. It is established that the way in which privately optimal R&D deviates from the first-best level depends on the kind of technical change in pollution abatement. Counterintuitively polluters might overinvest into R&D in pollution control if compensation falls short of harm, and may underinvest if compensation exceeds harm.

11/02971 Relationship between construction characteristics and carbon emissions from urban household operational energy usage

Ye, H. *et al. Energy and Buildings*, 2011, 43, (1), 147–152.

Carbon emitted from urban metabolism constitutes a substantial proportion of the anthropogenic greenhouse gas emission, which is at least partially responsible for the recent global warming. Part of the urban carbon emission comes from residential energy consumption. Given the ongoing rapid urbanization and strict emission-reduction requirement, understanding the urban home energy usage carbon emission (UHEUCE) is of great importance to optimize the sustainability of social and economic developments in China. For this reason, a survey has been conducted to exam the condition of home energy usage in Xiamen Island, south-east China. This study was based on 340 valid responses and a general linear model for univariate method. The analysis showed (1) among the residential building characteristics, window thermal insulation has the greatest effect on UHEUCE. (2) Construction age and wall thermal insulation could also influence UHEUCE in areas where summer is hot and winter is warm. The better heat prohibiting effect of external wall and window, as well as the newer construction, the more UHEUCE can be generated. The survey provided helpful first-hand data for design and planning on urban energy saving, emission reduction, and for relevant scientific researches.

11/02972 Reliability assessment of safety instrumented systems subject to different demand modes

Liu, Y. and Rausand, M. *Journal of Loss Prevention in the Process Industries*, 2011, 24, (1), 49–56.

Safety instrumented systems (SISs) are commonly used in the process industry, to respond to hazardous events. In line with the important standard IEC 61508, SISs are generally classified into two types: low-demand systems and high-demand systems. This article explores this classification by studying the SIS reliability for varying demand rates, demand durations, and test intervals. The approach is based on Markov models and is exemplified by two simple system configurations. The SIS reliability is quantified by the probability of failure on demand (PFD) and the frequency of entering a hazardous state that will lead to an accident if the situation is not controlled by additional barriers. The article concludes that very low-demand systems are similar and may be treated as a group. The same applies to very high-demand system. Between these group, there is a rather long interval where the demand rate is neither high-demand nor low-demand. These medium-demand systems need a specific treatment. The article shows that the frequency of entering into a hazardous state increases with the demand rate for low-demand systems, while it is nearly independent of both the demand rate and the demand duration for high-demand systems. The PFD is an adequate measure for the SIS reliability for low-demand systems, but may be confusing and difficult to interpret for high-demand systems.

11/02973 Suitability analysis of advanced diesel combustion concepts for emissions and noise control

Torregrosa, A. J. *et al. Energy*, 2011, 36, (2), 825–838.

During the past few years, the preservation of the atmospheric environment has played an increasingly important role in society. The diesel engine can be considered an environmentally friendly engine because of its low consumption and the subsequent carbon dioxide (CO_2) emissions reduction. However, in the near future it will face strong restrictive emission standards, which demand that the current nitrogen oxides (NO_x) and soot emissions are halved. To comply with these restrictions new combustion concepts are emerging, such as PCCI (premixed charge compression ignition), in which the fuel burns in premixed conditions. Combustion noise is thus deteriorated and consequently end-users could be reluctant to drive vehicles powered with diesel engines and their potential for environment preservation could be missed. In this paper, diesel combustion is addressed through the analysis of performance, emissions and combustion noise in order to evaluate the suitability of PCCI engines for automotive applications. The results show that PCCI combustion offers great possibilities to fulfil future emission restrictions, but the engine noise is strongly deteriorated. The great sensitivity of users to this factor requires vehicle manufacturers to focus their efforts on the optimization of passive solutions for implementing the PCCI concept in passenger car and light-duty engines, even with the subsequent increase in the cost of vehicle. This aspect is less restrictive in heavy-duty engines, since the great benefits in emissions reduction compensate the deterioration of engine noise.

11/02974 The effects of environmental policies on the abatement investment decisions of a green firm

Saltari, E. and Travaglini, G. *Resource and Energy Economics*, 2011, 33, (3), 666–685.

This paper focuses on environmental policies aimed at rising investment in pollution abatement capital. The authors assume that ecological uncertainty, i.e. uncertainty over the dynamics of pollution, affects firm investment decisions. Capital irreversibility is not postulated but endogenized using a quadratic adjustment cost function. Using this framework, they study the effects of environmental policies considering taxes on polluting inputs and subsidies to reduce the cost of abatement capital. Environmental policies promoted to enforce abatement capital may generate the unexpected result of reducing the abatement investment rate.

11/02975 Understanding household energy consumption patterns: when ‘west is best’ in Metro Manila

Sahakian, M. D. *Energy Policy*, 2011, 39, (2), 596–602.

This paper addresses the topic of energy and development through a multi-disciplinary and systemic approach that combines environmental considerations with a social understanding of consumption. The focus is on electricity usage in the home and specifically lighting and cooling. Set in the urban megapolis of Metro Manila, the Philippines, energy consumption is first placed in its biophysical perspective: the energy sources and electricity grid are presented, in relation to the Philippines as well as the region. The research findings then explore the social and cultural drivers behind household electricity consumption, revealing in several examples the strong influence of globalization – understood here as the flow of people, remittances, images and ideas. Policy recommendations are provided, based on the research results, with concluding remarks relevant to other similar contexts.

11/02976 Understanding public responses to offshore wind power

Haggett, C. *Energy Policy*, 2011, 39, (2), 503–510.

This paper is about understanding the role and importance of public responses to offshore wind power. It builds on a framework for understanding social acceptance and opposition to onshore turbines, and reviews the emerging research on offshore wind. While less is known about how people will respond to offshore than onshore wind, there is now an emerging body of research. From this literature, several common factors which influence responses have emerged and are discussed here: the (continued) role of visual impact; place attachment to the local area; lack of tangible benefits; relationships with developers and outsiders; and the role of the planning and decision-making systems. The paper argues that, as with onshore developments, the public should be included in decision-making about offshore wind farms, and that they have a key role which should not be underestimated. The paper concludes with some thoughts about the means to involve people and how effected communities might be effectively acknowledged, identified and engaged.

CO_2, NO_x, SO_2 and particulate emissions

11/02977 Adsorption and reduction of NO_2 over activated carbon at low temperature

Gao, X. *et al. Fuel Processing Technology*, 2011, 92, (1), 139–146.

The reactive adsorption of NO_2 over activated carbon (AC) was investigated at 50 °C. Both the NO_2 adsorption and its reduction to NO were observed during the exposure of AC to NO_2. Temperature programmed desorption (TPD) was then performed to evaluate the nature and thermal stability of the adsorbed species. Adsorption and desorption processes have been proposed based on the nitrogen and oxygen balance data. The micropores in AC act as a nano-reactor for the formation of –C(ONO_2) complexes, which is composed by NO_2 adsorption on existing –C(O) complexes and the disproportionation of adsorbed NO_2. The generated –C(ONO_2) complexes are decomposed to NO and NO_2 in the desorption step. The remaining oxygen complexes can be desorbed as CO and CO_2 to recover the adsorptive and reductive capacity of AC.

11/02978 Artificial weathering pools of calcium-rich industrial waste for CO_2 sequestration

Morales-Flórez, V. *et al. Chemical Engineering Journal*, 2011, 166, (1), 132–137.

Processes of carbonation of calcium-rich aqueous industrial wastes from acetylene production were performed mimicking rock weathering, using the atmospheric carbon dioxide as reactant. This residue was carbonated exposing it to the air in artificial pools with controlled solid-to-liquid and surface-to-volume ratios, and the efficiency of this simple mineral carbonation process was maximized. Considering realistic values of just one acetylene production plant, the intelligent handling of the calcium-rich waste would make it possible to counteract the emission of around 800 t of carbon dioxide per year, so the CO_2 emissions of the acetylene production could be completely compensated and its carbon footprint significantly reduced. X-ray diffraction patterns and thermogravimetric analyses reported the conversion, up to 88%, of the calcium hydroxide into calcium carbonate under atmospheric conditions. So, considering a realistic industrial scale-up, 476 kg of CO_2 could be captured with 1 t of dry waste. The morphology of the grains is resolved by electron microscopy, and can be described as needles 15 nm wide and 200 nm long arranged in grains smaller than 1 micron. The nanometric textural parameters (nanometric pores and particles having a specific surface area $\sim 50\,m^2/g$) are used to design an efficient carbon fixation procedure. The aim of this work is to propose this simple carbonation technology, based on aqueous alkaline industrial waste, as a contribution to reducing global CO_2 emissions.

11/02979 Carbon dioxide storage risk assessment: analysis of caprock fracture network connectivity

Smith, J. *et al. International Journal of Greenhouse Gas Control*, 2011, 5, (2), 226–240.

A geomechanical risk assessment methodology for CO_2 storage has been developed which analyses the connectivity of networks created by fractures in the caprock prior to and post injection. Emphasis is placed on assimilating into the results the uncertainty in the fracture properties at a particular site. The methodology uses percolation theory and involves modelling large numbers of realizations of the possible distribution of fractures in the caprock and testing whether these realizations contain a network of connected fractures spanning the model region. In addition, shear and tensile failure criteria are applied probabilistically so as to honour the uncertainties present in measurements and models. The results of failure analysis are then used to investigate changes in the caprock fracture network connectivity post injection. The procedures of modifying fracture properties according to a failure analysis and modelling the connectivity of fracture networks are demonstrated with an example study and compared to a deterministic formulation.

11/02980 Characteristic of coal combustion in oxygen/carbon dioxide atmosphere and nitric oxide release during this process

Niu, S.-L. *et al. Energy Conversion and Management*, 2011, 52, (1), 532–537.

Combustion characteristic of a bituminous coal and an anthracite coal in oxygen/carbon dioxide (O_2/CO_2) atmosphere is investigated in a thermogravimetric (TG) analyser. The characteristic parameters, which are deduced from the TG–DTG (differential thermogravimetric) curves, show that the coal combustion process is basically kept consistent in O_2/CO_2 and O_2/N_2 atmosphere at the O_2 concentration of 20%. The Coats–Redfern method with the reaction order of 1.25 could perfectly describe the combustion process in these two different atmospheres through the calculation of the kinetic parameters for the two coals. Nitric oxide (NO) release is concentrated in a narrower time period in O_2/CO_2 atmosphere compared with the one in O_2/N_2 atmosphere during the coal combustion process. Though the high value of the NO release rate peak, the total conversion of the fuel-N to NO is strongly depressed in O_2/CO_2 atmosphere, and at 1473 K, the conversion is reduced by 28.99% for the bituminous coal and 22.54% for the anthracite coal, respectively. When O_2 concentration is increased from 20% to 40% in O_2/CO_2 atmosphere, the coal combustion property is obviously improved with the shift of the whole process into the lower temperature zone and the more intensive of the reaction occurrence in a narrower temperature range. However, the total fuel-N to NO conversion is increased accordingly. For bituminous coal the increase is 17.22% at 1073 K and 20.51% at 1173 K, and for anthracite coal the increase is 15.73% at 1073 K and 16.19% at 1173 K.

11/02981 Comparative study of regulated and unregulated gaseous emissions during NEDC in a light-duty diesel engine fuelled with Fischer Tropsch and biodiesel fuels

Bermúdez, V. *et al. Biomass and Bioenergy*, 2011, 35, (2), 789–798.

In this study, regulated and unregulated gaseous emissions and fuel consumption with five different fuels were tested in a four-cylinder, light-duty diesel EURO IV typically used for the automotive vehicles in Europe. Three different biodiesel fuels obtained from soybean oil, rapeseed oil and palm oil, a Fischer–Tropsch fuel and an ultra-low sulfur diesel were studied. The test used was the New European Driving Cycle (NEDC), this allowed tests to be carried out on an engine warmed up beforehand to avoid the effect of cold starts and several tests a day. Regulated emissions of NO_X, CO, HC and CO_2 were measured for each fuel. Unburned hydrocarbon speciation and formaldehyde were also measured in order to determine the maximum incremental reactivity (MIR) of the gaseous emissions. Pollutants were measured without the diesel oxidation catalyst (DOC) to gather data about raw emissions. When biodiesel was used, increases in regulated and unregulated emissions were observed and also significant increases in engine fuel consumption. The use of Fischer–Tropsch fuel, however, caused lower regulated and unregulated emissions and fuel consumption than diesel.

11/02982 Convergence in per capita CO_2 emissions: a robust distributional approach

Criado, C. O. and Grether, J.-M. *Resource and Energy Economics*, 2011, 33, (3), 637–665.

This paper investigates the convergence hypothesis for per capita CO_2 emissions with a panel of 166 world areas covering the period 1960–2002. The analysis is based on the evolution of the spatial distributions over time. Robust measures of dispersion, asymmetry, peakedness and two non-parametric distributional tests – shape equality and multimodality – are used to assess spatial time differences. A robust normal reference bandwidth is also applied to estimate Markov's transition laws and its subsequent ergodic (long-run) distributions. The results point toward non-stationary, flattening and right-skewed spatial distributions before the oil price shocks of the 1970s and more stable and symmetric shapes between 1980 and 2000 at the world level and for many country groupings (similar income, geographic neighbours, institutional partners). In the latter period, group-specific convergence patterns emerge with the clearest single-peaked and compact density shapes being reached in the wealthy, well-integrated and European countries during the last years of the panel. No significant multimodality is formally detected in the world distribution over the whole period. The Markov analysis suggests more divergence and larger per capita emissions for the world in the long run, with a doubling in median emissions and stable pollution gaps during the first 50 years of the transition. A variety of steady state distributions are identified in the country subsets.

11/02983 Determinants of carbon dioxide emissions: empirical evidence from 69 countries

Sharma, S. S. *Applied Energy*, 2011, 88, (1), 376–382.

This study investigates the determinants of carbon dioxide emissions (CO_2) for a global panel consisting of 69 countries using a dynamic panel data model. To make the panel data analysis more homogenous, the determinants of CO_2 emissions for a number of sub-panels are also investigated. These sub-panels are constructed based on the income level of countries. In this way, three income panels are obtained; namely, high income, middle income, and low income panels. The time component of the dataset is 1985–2005 inclusive. The main findings are that trade openness, per capita GDP, and energy consumption, proxied by per capita electric power consumption and per capita total primary energy consumption, have positive effects on CO_2 emissions. Urbanization is found to have a negative impact on CO_2 emissions in high income, middle income, and low income panels. For the global panel, only GDP per capita and per capita total primary energy consumption are found to be statistically significant determinants of CO_2 emission, while urbanization, trade openness, and per capita electric power consumption have negative effects on the CO_2 emissions.

11/02984 Economically efficient operation of CO_2 capturing process part I: self-optimizing procedure for selecting the best controlled variables

Panahi, M. and Skogestad, S. *Chemical Engineering and Processing: Process Intensification*, 2011, 50, (3), 247–253.

The authors study optimal operation of a post-combustion CO_2 capturing process where optimality is defined in terms of a cost function that includes energy consumption and penalty for released CO_2 to the air. Three different operational regions are considered. In region I, with a nominal flue gas flowrate, there are two optimally unconstrained degrees of freedom (DOFs) and the corresponding best self-optimizing controlled variables (CVs) are found to be the CO_2 recovery in the absorber and the temperature at tray no. 16 in the stripper. In the region II, with an increased flue gas flowrate, the heat input is saturated and there is one unconstrained DOF left. The best CV is temperature at tray no. 13 in the stripper. In region III, when the flue gas flowrate is further increased, the process reaches the minimum allowable CO_2 recovery of 80% and there is no unconstrained DOF. This is the bottleneck and a controller is needed to adjust the feed flowrate to avoid violating this minimum. The exact local method and the maximum gain rule are applied to find the best CVs in each region.

11/02985 Embodied emissions abatement – a policy assessment using stochastic analysis

Acquaye, A. *et al. Energy Policy*, 2011, 39, (1), 429–441.

Policymakers traditionally focus on regulating operational energy use in buildings, ignoring other life cycle components such as embodied energy even though this may account for a significant portion of life cycle emissions. Data relating to embodied energy and emissions in buildings is limited. However, stochastic techniques can be used to estimate the distribution of such emissions from buildings. This helps policymakers identify which instruments are appropriate for achieving emissions reductions. A primary aim of this paper is to demonstrate this approach using a sample of apartment buildings in Ireland. A Monte-Carlo simulation suggests that the average probability distribution of embodied greenhouse gases in a sample of Irish apartment buildings is characteristic of a Wakeby distribution with a long tail which can be targeted for improvement through the implementation of appropriate policies. Two policies are investigated: one regulatory whereby the embodied emissions of building materials are limited to the 80th percentile of their current distributions; and one informational where buildings are given an embodied emissions rating. It is estimated that such policies could result in an average reduction of 450 gCO_2-eq/€ for the sample of apartment buildings analysed and could result in savings of €2 billion to EU-27 countries in avoided carbon credits.

11/02986 Energy flow and greenhouse gas emissions in organic and conventional sweet cherry orchards located in or close to Natura 2000 sites

Litskas, V. D. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1302–1310.

An energy analysis in orchards is useful to deciding best management strategies. The objective of this study was to evaluate, by selecting organic and conventional sweet cherry orchards located in/or close to Natura 2000 sites (a) the energy flow between the two farming systems and (b) the effect of farming system to gas emissions (CO_2, CH_4 and N_2O). Twenty farms (two conventional and two organic over five locations) were selected during 2003–2004. Means averaged over all locations for insecticides and fungicides application, fuel, insecticides, fungicides, non-renewable energy inputs, energy shoot outputs, energy fruit outputs, energy shoot + fruit outputs, fruit production, shoot efficiency, fruit efficiency, shoot + fruit efficiency, non-renewable energy efficiency, gas emissions were higher in conventional than in organic orchards, while fertilizer application, harvesting, fertilizers, labour, total energy inputs, renewable energy inputs, intensity and non-renewable energy consumption were higher in organic orchards. Means averaged over two farming systems for fertilizer, insecticide and fungicide application were higher in GRL2 and GRL5. The means averaged over two systems for transportation had the highest value in GRL4 and the lowest in GRL5. Finally, means averaged over two farming systems for labour had the highest value in GRL2. Non-renewable energy inputs as percent of total inputs were 82.63 and 52.42% in conventional and organic sweet cherry orchards respectively. The results show that organic farming systems could reduce non-renewable energy inputs and gas emissions in an efficient way in areas related to Natura 2000 sites.

11/02987 Experimental study on nitric oxide reduction through calcium propionate reburning

Niu, S. *et al. Energy*, 2011, 36, (2), 1003–1009.

Performances of calcium propionate (CP) on nitric oxide (NO) reduction are experimentally investigated on a drop tube furnace system from basic reburning (BR), Thermal De-NO_x and advanced reburning (AR) and it is demonstrated to be feasible of using CP as reburning fuel. BR could supply about 80% efficiency with reburning fuel fraction (Rff) and residence time (τ) kept 20–25% and 0.7 s, respectively. Also, oxygen concentration is required to be less than 4%. However, initial NO concentration is not important to reduction. Characteristics of Thermal De-NO_x are also studied. The maximum efficiency of 85.34% could be achieved at 1273 K with mole ratio of ammonia to nitric oxide (β) equal to 1.75. The corresponding 'temperature window' is 1215–1341 K. From 2% to 6% of oxygen concentration, the efficiency of Thermal De-NO_x is constantly depressed by 16.17%. The performances of advanced reburning are greatly optimized and higher efficiency could be achieved using less calcium propionate and ammonia. At 1273 K, efficiency of 93.37% is supplied by AR with Rff = 19.83% and $\beta = 0.8$. Also, the corresponding 'temperature window' is broadened to 1195–1355 K which is 1.27 times of the one in Thermal De-NO_x at $\beta = 1.75$. Meanwhile, the impact of oxygen concentration on NO reduction is weakened in AR.

11/02988 Impact of dopants on the sulfation, desulfation and NO_x reduction performance of Ba-based NO_x storage-reduction catalysts

Toops, T. J. *et al. Catalysis Today*, 2011, 160, (1), 131–136.

The performance of a NO_x storage-reduction (NSR) catalyst is strongly dependent on the relative stabilities of nitrates and sulfates on the catalyst surface. This effort studies the effects of introducing 5 mol% La, Ca, and K-dopants into a BaO phase of a model Pt/Ba/Al_2O_3 NSR catalyst. The dopants were chosen with a range of properties to affect the BaO lattice spacing and/or the number of oxygen vacancies. The resulting changes in the storage material, in turn, impact the stability of stored nitrates and sulfates, as measured by NO_x conversions and desulfation temperatures. The Ca- and La-doped material shows equivalent or better NO_x reduction performance between 200 and 400 °C, while the K-doped NSR catalyst showed significant decreases in performance at 200 °C but maintained the high performance at 300 and 400 °C. Following the performance measurements, the samples are then sulfated to 5.5 mg S/gcat and desulfated to 1000 °C. All NSR catalysts generally show similar desulfation behaviour, but in determining the temperature of 20% sulfur removal ($T_{20\%}$), it is shown that the Ca + Ba sample has a 25 °C lower $T_{20\%}$ than both the Ba-only and La + Ba samples, while K + Ba is 70 °C higher. Additional Ca-based samples were than prepared at the 10, 20 and 100 mol% levels. The higher Ca-doped materials show similar NO_x reduction performance, but the 5% Ca + Ba sample maintains the lowest $T_{20\%}$. Interestingly, the Ca-only sample has a $T_{20\%}$ that is 60 °C higher than the Ba-only NSR catalyst, which indicates that the introduction of 5% Ca into the Ba-lattice has a synergistic effect in lowering the desulfation temperature.

11/02989 Integrating desulfurization with CO_2-capture in chemical-looping combustion

Solunke, R. D. and Veser, G. *Fuel*, 2011, 90, (2), 608–617.

Chemical looping combustion (CLC) is an emerging technology for clean combustion. The authors have previously demonstrated that the embedding of metal nanoparticles into a nanostructured ceramic matrix can result in unusually active and sinter-resistant nanocomposite oxygen carrier materials for CLC which maintain high reactivity and high-temperature stability even when sulfur contaminated fuels are used in CLC. Here, the authors propose a novel process scheme for *in situ* desulfurization of syngas with simultaneous CO_2-capture in chemical looping combustion by using these robust nanocomposite oxygen carriers simultaneously as sulfur-capture materials. The authors found that a nanocomposite Cu-BHA carrier can indeed strongly reduce the H_2S concentration in the fuel reactor effluent. However, during the process the support matrix is also sulfidized and takes part in the redox process of CLC. This results in SO_2 production during the reduction of the oxygen carrier and thus limits the degree of desulfurization attainable with this kind of carrier. Nevertheless, the results suggest that simultaneous desulfurization and CO_2 capture in CLC is feasible with Cu as oxygen carrier as long as appropriate carrier support materials are chosen, and could result in a novel, strongly intensified process for low-emission, high efficiency combustion of sulfur contaminated fuel streams.

11/02990 Investigation into a gas–solid–solid three-phase fluidized-bed carbonator to capture CO_2 from combustion flue gas

Cao, C. *et al. Chemical Engineering Science*, 2011, 66, (3), 375–383.

A two-dimensional (2D) transient model was developed to simulate the local hydrodynamics of a gas (flue gas)–solid (CaO)–solid ($CaCO_3$) three-phase fluidized-bed carbonator using the computational fluid dynamic method, where the chemical reaction model was adopted to determine the molar fraction of CO_2 at the exit of carbonator and the partial pressure of CO_2 in the carbonator. This investigation was intended to improve an understanding of the chemical reaction effects of CaO with CO_2 on the CO_2 capture efficiency of combustion flue gases. For this purpose, the authors Fluent 6.2 to predict the CO_2 capture efficiency for different operation conditions. The adopted model concerning the reaction rate of CaO with CO_2 is joined into the

CFD software. Model simulation results, such as the local time-averaged CO_2 molar fraction and conversion of CaO, were validated by experimental measurements under varied operating conditions, e.g. the fraction of active CaO, chemical reaction temperature, particle size, and cycle number at different locations in a gas–solid–solid three-phase fluidized bed carbonator. Furthermore, the local transient hydrodynamic characteristics, such as gas molar fraction and partial pressure were predicted reasonably by the chemical reaction model adopted for the dynamic behaviours of the gas–solid–solid three-phase fluidized bed carbonator. On the basis of this analysis, capture CO_2 strategies to reduce CO_2 molar fraction in exit of carbonator reactor can be developed in the future. It is concluded that a fluidized bed of CaO can be a suitable reactor to achieve very effective CO_2 capture from combustion flue gases.

11/02991 Saline-aquifer CO_2 sequestration in Japan – methodology of storage capacity assessment

Ogawa, T. *et al. International Journal of Greenhouse Gas Control*, 2011, 5, (2), 318–326.

A national saline-aquifer CO_2 storage capacity assessment has been carried out in Japan in two missions. In mission 1, candidate saline aquifers were classified in terms of the type of geological structure and the amount of data available. Storage capacity for the entire country was then estimated based upon oil and gas exploration data (146 billion tons of CO_2). The areas considered in the mission were located mostly offshore and far from large CO_2 emission sources. Mission 2 involved storage capacity estimation in 27 areas in the vicinity of large CO_2 emission sources. These areas had been excluded in the mission 1 capacity assessments. With national-scale geological survey results, a preliminary assessment was performed, and promising sedimentary basins were selected for more detailed examination. To date the overall storage capacity is still under discussion in mission 2, whereas a systematic way of evaluating data quality and quantity is proposed, and comparative studies on the storage capacity estimation is in progress.

11/02992 Technologies for increasing CO_2 concentration in exhaust gas from natural gas-fired power production with post-combustion, amine-based CO_2 capture

Li, H. *et al. Energy*, 2011, 36, (2), 1124–1133.

Enhanced CO_2 concentration in exhaust gas is regarded as a potentially effective method to reduce the high electrical efficiency penalty caused by CO_2 chemical absorption in post-combustion capture systems. The present work evaluates the effect of increasing CO_2 concentration in the exhaust gas of gas turbine based power plant by four different methods: exhaust gas recirculation (EGR), humidification (EvGT), supplementary firing (SFC) and external firing (EFC). Efforts have been focused on the impacts on cycle efficiency, combustion, gas turbine components, and cost. The results show that the combined cycle with EGR has the capability to change the molar fraction of CO_2 with the largest range, from 3.8 mol% to at least 10 mol%, and with the highest electrical efficiency. The EvGT cycle has relatively low additional cost impact as it does not require any bottoming cycle. The externally fired method was found to have the minimum impacts on both combustion and turbomachinery.

Hydrocarbon emissions

11/02993 Restricted carbon emissions and directed R&D support; an applied general equilibrium analysis

Bye, B. and Jacobsen, K. *Energy Economics*, 2011, 33, (3), 543–555.

The authors analyse welfare effects of supporting general versus emission-saving technological development when carbon emissions are regulated by a carbon tax. The authors use a computable general equilibrium model with induced technological change (ITC). ITC is driven by two separate, economically motivated research and development (R&D) activities, one general and one emission-saving specified as carbon capture and storage (CCS). The authors study public revenue neutral policy alternatives targeted towards general R&D and CCS R&D. Support to general R&D is the welfare superior. However, the welfare gap between the two R&D policy alternatives is reduced with higher carbon tax levels. For sufficiently high levels of the carbon tax equal subsidy rates are preferred.

11/02994 Thermal analysis of a partially ceramic coated piston: effect on cold start HC emission in a spark ignition engine

Cerit, M. *et al. Applied Thermal Engineering*, 2011, 31, (2–3), 336–341.

Effect of partially thermal barrier coating on piston temperature distribution and cold start hydrocarbon (HC) emissions of a spark ignition (SI) engine are investigated numerically and experimentally. A Thermal analysis was performed for both standard and coated pistons by using a commercial code, namely ANSYS. The engine tests were conducted on a single cylinder, water-cooled SI engine for both standard and coated cases. Analysis results show that the surface temperature of the coated piston part was increased up to 100 °C, which leads to an increase in air–fuel mixture temperature in the crevice and wall quenching regions. Thus, cold start HC emissions considerably decrease compared to the standard engine without any degradation in engine performance. Maximum decrease in HC emissions was 43.2% compared to the standard engine.

Life cycle analysis

11/02995 An embodied carbon and energy analysis of modern methods of construction in housing: a case study using a lifecycle assessment framework

Monahan, J. and Powell, J. C. *Energy and Buildings*, 2011, 43, (1), 179–188.

There is a growing interest in comparing the energy and consequential carbon embodied in buildings using different methods of construction and alternative materials. This paper compares the embodied carbon in a low energy, affordable house constructed using a novel offsite panellized modular timber frame system, in Norfolk UK with two traditional alternative scenarios. A lifecycle assessment (LCA) framework is used to conduct a partial LCA, from cradle to site, of the construction. An inventory of the materials and fossil fuel energy utilized in the construction was used to calculate the primary energy consumed and the associated embodied carbon. The embodied carbon was found to be 34.6 tonnes CO_2 for a three-bedroom semi-detached house, 405 $kgCO_2$ per m^2 of useable floor area. When compared with traditional methods of construction the modern methods of construction (MMC) house resulted in a 34% reduction in embodied carbon. Despite timber being the predominant structural and cladding material, concrete is the most significant material (by proportion) in embodied carbon terms, responsible for 36% of materials related embodied carbon.

11/02996 Biofuel or excavation? Life cycle assessment (LCA) of soil remediation options

Suer, P. and Andersson-Sköld, Y. *Biomass and Bioenergy*, 2011, 35, (2), 969–981.

The environmental consequences of soil remediation through biofuel or through dig-and-dump were compared using life cycle assessment (LCA). Willow (*Salix viminalis*) was actually grown *in situ* on a discontinued oil depot, as a phytoremediation treatment. These data were used for the biofuel remediation, while excavation-and-refill data were estimated from experience. The biofuel remediation had great environmental advantages compared to the *ex situ* excavation remediation. With the ReCiPe impact assessment method, which included biodiversity, the net environmental effect was even positive, in spite of the fact that the wood harvest was not utilized for biofuel production, but left on the contaminated site. Impact from the *Salix viminalis* cultivation was mainly through land use for the short rotation coppice, and through journeys of control personnel. The latter may be reduced when familiarity with biofuel as a soil treatment method increases. The excavation-and-refill remediation was dominated by the landfill and the transport of contaminated soil and backfill.

11/02997 Is it environmentally advantageous to use vegetable oil directly as biofuel instead of converting it to biodiesel?

Esteban, B. *et al. Biomass and Bioenergy*, 2011, 35, (3), 1317–1328.

The oil price instability and the measures taken to reduce the increase in greenhouse gas emissions are the main factors promoting the development and use of environmentally friendly energies. From an energy efficiency point of view, biofuels constitute a renewable energy source and its use helps to reduce energy dependency on fossil fuels. The most used biofuels for transport worldwide are biodiesel (BD) and bioethanol. However, there are other options such as straight vegetable oil (SVO). SVO can be small-scale produced in local cooperatives through pressing, filtering and conditioning processes which are much simpler than the ones required for BD production. In this study a comparative life cycle assessment (LCA) of two biofuels obtained from Spanish rapeseed, namely small-scale SVO and large-scale BD, is performed. The LCA methodology allows the two biofuels' production and their rate of consumption in a vehicle (a truck) to be compared. In this manner, it is possible to assess which is environmentally advantageous: to use SVO directly as biofuel or to convert it to BD. Moreover, LCA is used in the study to calculate the energy return on investment index (EROI) and an energy conversion ratio to evaluate which biofuel is more energy efficient. The obtained results show the environmental benefits of using SVO instead of BD by analysing representative impact categories defined by the CML and EDIP methods. A sensitivity analysis has also been conducted. EROI indexes for SVO and BD production show a clear preference for SVO as compared to BD.

11/02998 Life cycle cost and energy analysis of a net zero energy house with solar combisystem

Leckner, M. and Zmeureanu, R. *Applied Energy*, 2011, 88, (1), 232–241.

The net zero energy house (NZEH) presented in this paper is an energy efficient house that uses available solar technologies to generate at least as much primary energy as the house uses over the course of the year. The computer simulation results show that it is technically feasible to reach the goal of NZEH in the cold climate of Montreal. In terms of the life cycle energy use, which considers the operating and embodied energy of the house, the energy payback time is 8.4–8.7 years, when the NZEH is compared with an average house that complies with the provincial code. The energy payback ratio of the combisystem is 3.5–3.8 compared with the heating system of conventional house. By converting solar energy, the combisystem supplies at least 3.5 times more energy than the energy invested for manufacturing and shipping the system. The life cycle cost analysis of the NZEH shows, however, that due to the high cost of the solar technologies and the low cost of electricity in Montreal, financial payback is never achieved.

11/02999 Power generation scenarios for Nigeria: an environmental and cost assessment

Gujba, H. *et al. Energy Policy*, 2011, 39, (2), 968–980.

Exploratory scenarios for the power sector in Nigeria are analysed in this paper using possible pathways within the Nigerian context and then compared against the government's power expansion plan in the short to medium term. They include two fossil-fuel (FF and CCGT) and two sustainable-development-driven scenarios (SD1 and SD2). The results from the FF scenarios indicate this is the preferred outcome if the aim is to expand electricity access at the lowest capital costs. However, the annual costs and environmental impacts increase significantly as a consequence. The SD1 scenario, characterized by increased penetration of renewables, leads to a reduction of a wide range of environmental impacts while increasing the annual costs slightly. The SD2 scenario, also with an increased share of renewables, is preferred if the aim is to reduce GHG emissions; however, this comes at an increased annual cost. Both the SD1 and SD2 scenarios also show significant increases in the capital investment compared to the Government's plans. These results can be used to help inform future policy in the Nigerian electricity sector by showing explicitly the range of possible trade-offs between environmental impacts and economic costs both in the short and long terms.

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Supplies, policy, economics, forecasts

11/03000 A comparison of the energy and carbon implications of new systems of energy provision in new build housing in the UK

Monahan, J. and Powell, J. C. *Energy Policy*, 2011, 39, (1), 290–298.

The built environment needs to develop sustainable, decarbonized, low energy systems and approaches that are socially acceptable and economically beneficial. The UK's mainstream house construction industry is being driven, through policy and regulation, towards achieving this end without evidence of how these new systems of provision are used by passively adopting households. In this paper energy use, consequential emissions of CO_2, and annual running costs for a case study comprising 14 newly constructed low energy affordable homes are evaluated. Four different energy typologies are compared: ground sourced heat pumps; active solar (thermal and photovoltaic); passive solar and mechanical ventilation with heat recovery; conventional high efficiency gas boiler. The carbon embodied in construction and emitted over a 20-year occupation period for each typology is calculated. Ground source heat pumps have the highest annual primary energy demand, CO_2 emission and annual running costs over the 20-year period. The homes with active solar technologies provided most benefit across all three evaluation criteria. Energy and CO_2 emissions associated with end uses other than heating were similar to the British average. This poses significant questions on the probability of policy application in the real world to deliver projected reductions in emissions of CO_2.

11/03001 Advanced vehicles: costs, energy use, and macroeconomic impacts

Wang, G. *Journal of Power Sources*, 2011, 196, (1), 530–540.

Advanced vehicles and alternative fuels could play an important role in reducing oil use and changing the economy structure. The authors developed the costs for advanced vehicles and energy (CAVE) model to investigate a vehicle portfolio scenario in California during 2010–2030. Then they used a computable general equilibrium model to estimate macroeconomic impacts of the advanced vehicle scenario on the economy of California. Results indicate that, due to slow fleet turnover, conventional vehicles are expected to continue to dominate the on-road fleet and gasoline is the major transportation fuel over the next two decades. However, alternative fuels could play an increasingly important role in gasoline displacement. Advanced vehicle costs are expected to decrease dramatically with production volume and technological progress; e.g. incremental costs for fuel cell vehicles and hydrogen could break even with gasoline savings in 2028. Overall, the vehicle portfolio scenario is estimated to have a slightly negative influence on California's economy, because advanced vehicles are very costly and, therefore, the resulting gasoline savings generally cannot offset the high incremental expenditure on vehicles and alternative fuels. Sensitivity analysis shows that an increase in gasoline price or a drop in alternative fuel prices could offset a portion of the negative impact.

11/03002 An analysis of energy efficiency investments' environment in Greece – the potential role of JESSICA instrument

Patlitzianas, K. D. *Energy Conversion and Management*, 2011, 52, (1), 366–373.

The most important constraint toward the successful implementation of the energy efficiency investments in Greece remains the absence of appropriate and competitive financial schemes. Energy efficiency improvements seems to be one of the areas that JESSICA instrument should focus on in the case of Greece, considering that energy efficiency constitutes a major component of sustainable urban development. The scope of this paper is to present, in an updating way, an analysis of energy efficiency investments' environment in Greece as well as to examine the potential role of the JESSICA instruments, aiming to the supporting of the real implementation of energy efficiency investments in Greece. In addition, a rigid methodological note is presented for the analysis as well as evaluation of the JESSICA instruments for energy efficiency projects in Greece.

11/03003 An emerging equilibrium in the EU emissions trading scheme

Bredin, D. and Muckley, C. *Energy Economics*, 2011, 33, (2), 353–362.

The European Union's emissions trading scheme (ETS) is the key policy instrument of the European Commission's climate change program aimed at reducing greenhouse gas emissions to 8% below 1990 levels by 2012. A critically important element of the EU ETS is the establishment of a market determined price for EU allowances. This article examines the extent to which several theoretically founded factors including, economic growth, energy prices and weather conditions determine the expected prices of the European Union CO_2 allowances during the 2005 through to the 2009 period. A novel aspect of the study is that heavily traded futures instruments that have an expiry date in phase 2 of the EU ETS are examined. This study adopts both static and recursive versions of the Johansen multivariate cointegration likelihood ratio test as well as a variation on this test with a view to controlling for time varying volatility effects. The results are indicative of a new pricing regime emerging in phase 2 and point to a maturing market driven by the fundamentals. These results are valuable both for traders of European Union allowances and for those policy makers seeking to improve the design of the European Union ETS.

11/03004 An energy management system for a directly-driven electric scooter

Yang, Y.-P. *et al. Energy Conversion and Management*, 2011, 52, (1), 621–629.

An energy management system with an electronic gearshift and regenerative braking is presented to improve the gross efficiency and driving range of an electric scooter, driven directly by a four-phase axial-flux DC brushless wheel motor. The integration of stator windings, batteries, ultracapacitors, and a digital controller constitutes an energy management system, which features smooth electronic gear shifting and regenerative braking. The gross efficiency of the experimental scooter is improved in the drivable range by 20% with respect to that without regenerative braking. The battery-to-wheel efficiency was also above 70% for both low- and high-speed gears.

11/03005 China's energy security: perception and reality

Leung, G. C. K. *Energy Policy*, 2011, 39, (3), 1330–1337.

China, now the world's second-largest economy, is worried about energy security, which underpins the core objectives of Beijing and the political legitimacy of the Communist Party of China. The purpose of this study is to explore certain popular myths about China's energy security. The study consists of six parts. After the introduction, it formulates the obscure concept of 'energy security' and attempts to contextualize it with 'Chinese characteristics.' Then it explicitly points out that the largest driver of oil demand by China as the 'world's factory' is transport instead of industry. Next, it explores the effectiveness of transnational pipelines as a measure of energy security and explains why they are less effective than many observers have previously assumed. Furthermore, it investigates the global expansion of Chinese national oil companies and questions their actual contribution to energy security. A few concluding remarks then follow.

11/03006 Comfort of workers in office buildings: the European HOPE project

Bluyssen, P. M. *et al. Building and Environment*, 2011, 46, (1), 280–288.
Previous studies have shown that building, social and personal factors can influence one's perceived health and comfort. The aim of the underlying study was to get a better understanding of the relationships between these factors and perceived comfort. Self-administered questionnaires from 5732 respondents in 59 office buildings and building-specific data from the 'European health optimization protocol for energy-efficient buildings' study were used. Principal component analysis, reliability analyses, and linear regression analysis were performed. The outcome showed that perceived comfort is strongly influenced by several personal, social and building factors and that their relationships are complex. Results showed that perceived comfort is much more than the average of perceived indoor air quality, noise, lighting and thermal comfort responses. Perceived comfort is a phenomenon that deserves more research.

11/03007 Dynamics of final sectoral energy demand and aggregate energy intensity

Lescaroux, F. *Energy Policy*, 2011, 39, (1), 66–82.
This paper proposes a regional and sectoral model of global final energy demand. For the main end-use sectors of consumption (industrial, commercial and public services, residential and road transportation), per-capita demand is expressed as an S-shaped function of per-capita income. Other variables intervene as well, like energy prices, temperatures and technological trends. This model is applied on a panel of 101 countries and three aggregates (covering the whole world) and it explains fairly well past variations in sectoral, final consumption since the beginning of the 2000s. Further, the model is used to analyse the dynamics of final energy demand, by sector and in total. The main conclusion concerns the pattern of change for aggregate energy intensity. The simulations performed show that there is no *a priori* reason for it to exhibit a bell-shape, as reported in the literature. Depending on initial conditions, the weight of basic needs in total consumption and the availability of modern commercial energy resources, various forms might emerge.

11/03008 Effects of Kosovo's energy use scenarios and associated gas emissions on its climate change and sustainable development

Kabashi, S. *et al. Applied Energy*, 2011, 88, (2), 473–478.
Climate change will be the first truly global challenge for sustainability. Energy production and consumption from fossil fuels has central role in respect to climate change, but also to sustainability in general. Because climate change is regionally driven with global consequences and is a result of economic imperatives and social values, it requires a redefinition as to the balance of these outcomes globally and regionally in Kosovo. Kosovo as one of the richest countries in lignite in Europe, with 95–97% of its electric power production from lignite and with 90% of vehicles over 10 years old, represents one of the regions with the greatest ratio of CO_2 emissions per unit of GDP, as well as one of the countries with the most polluted atmosphere in Europe. Modelling was carried out regionally for Kosovo for two dynamical systems which are the main emitters of greenhouse gases (CO_2, CH_4, NO_x, etc.) and air pollutants (CO, SO_2, dust CH_x, etc.): electricity generation and transportation emissions systems, for the time period 2000–2025. Various energy scenarios of the future are shown. The study demonstrates that a transition to environmental- compatible sustainable energy use in Kosovo is possible. Implementing the emission reduction policies and introducing new technologies in electrical power production and transportation in Kosovo ensure a sustainable future development in Kosovo, electric power production and transport that become increasingly environmentally compatible.

11/03009 Energy consumption, costs and environmental impacts for urban water cycle services: case study of Oslo (Norway)

Venkatesh, G. and Brattebø, H. *Energy*, 2011, 36, (2), 792–800.
Energy consumption in the operation and maintenance phase of the urban water and wastewater network is directly related to both the quantity and the desired quality of the supplied water/treated wastewater – in other words, to the level of service provided to consumers. The level of service is dependent on not just the quantity and quality of the water but also the state of the infrastructure. Maintaining the infrastructure so as to be able to provide the required high level of service also demands energy. Apart from being a significant operational cost component, energy use also contributes to life-cycle environmental impacts. This paper studies the direct energy consumption in the operation and maintenance phase of the water and wastewater system in Oslo; and presents a break-up among the different components of the network, of quantities, costs and environmental impacts. Owing to the diversity in the periods of time for which comprehensive data for the whole system are available, the study period is restricted to the years 2000–2006. The per-capita annual consumption of energy in the operational phase of the system varied between 220 and 260 kWh; and per-capita annual expenses on energy in inflation-adjusted year-2006-euros ranged between €6.5 and 11. The energy consumed on the upstream, per unit volume water supplied was around 0.4 kWh on average, while the corresponding value for the downstream was 0.8 kWh per cubic metre wastewater treated. The upstream greenhouse gas (GHG) emissions ranged between 70 and 80 g per cubic metre of water supplied, about 22% greater on average than the corresponding specific GHG emissions on the downstream.

11/03010 Energy dispatching analysis of lightning surges on underground cables in a cable connection station

Chang, H.-C. *et al. Energy Conversion and Management*, 2011, 52, (1), 693–702.
The paper aimed to simulate the transient over-voltage phenomena which occur at 345 kV and 161 kV underground cables, when lightning strikes on or near the cable connection station, by using the electromagnetic transients program (EMTP). A feasibility study on changing related parameters, as well as cable connections and grounding methods to reduce the impact caused by lightning strikes, will be thoroughly conducted. The various components required for a detailed simulation including; lightning surges, transmission line and tower, arrester, and underground cables are all considered. Then, the transient voltage of the cables will be analysed under different situations including; connection methods, grounding locations, length of the grounding wire of arrester, and the grounding resistance for different locations. The simulation results show that the length of the grounding wire is more sensitive to the transient over-voltage which occurred when a common grounding topology was adopted. In contrast, the use of an independent grounding topology resulted in a reduction of the grounding resistance, which effectively decreased the over-voltage, thereby avoiding surpassing the shielding voltage level of the cable, caused by the rise of ground voltage.

11/03011 Energy policies avoiding a tipping point in the climate system

Bahn, O. *et al. Energy Policy*, 2011, 39, (1), 334–348.
Paleoclimate evidence and climate models indicate that certain elements of the climate system may exhibit thresholds, with small changes in greenhouse gas emissions resulting in non-linear and potentially irreversible regime shifts with serious consequences for socio-economic systems. Such thresholds or tipping points in the climate system are likely to depend on both the magnitude and rate of change of surface warming. The collapse of the Atlantic thermohaline circulation (THC) is one example of such a threshold. To evaluate mitigation policies that curb greenhouse gas emissions to levels that prevent such a climate threshold being reached, the authors use the MERGE model of Manne, Mendelsohn and Richels. Depending on assumptions on climate sensitivity and technological progress, the analysis shows that preserving the THC may require a fast and strong greenhouse gas emission reduction from today's level, with transition to nuclear and/or renewable energy, possibly combined with the use of carbon capture and sequestration systems.

11/03012 Energy use pattern and benchmarking of selected greenhouses in Iran using data envelopment analysis

Omid, M. *et al. Energy Conversion and Management*, 2011, 52, (1), 153–162.
This paper studies the degree of technical efficiency (TE) and scale efficiency (SE) of selected greenhouses in Iran and describes the process of benchmarking energy inputs and cucumber yield. Enquiries on 18 greenhouses were conducted in a face-to-face interviewing during September–December 2008 period. A non-parametric data envelopment analysis (DEA) technique was applied to investigate the degree of TE and SE of producers, and evaluate and rank productivity performance of cucumber producers based on eight energy inputs: human labour, diesel, machinery, fertilizers, chemicals, water for irrigation, seeds and electricity, and output yield values of cucumber. DEA optimizes the performance measure of each greenhouse or

decision making unit (DMU). Specifically, the DEA was used to compare the performance of each DMU in region of increasing, constant or decreasing return to scale in multiple-inputs situations. The CRS model helped us to decompose the pure TE into the overall TE and SE components, thereby allowing investigating the scale effects. The results of analysis showed that DEA is an effective tool for analysing and benchmarking productive efficiency of greenhouses. The VRS analysis showed that only 12 out of the 18 DMUs were efficient. The TE of the inefficient DMUs, on average, was calculated as 91.5%. This implies that the same level of output could be produced with 91.5% of the resources if these units were performing on the frontier. Another interpretation of this result is that 8.5% of overall resources could be saved by raising the performance of these DMUs to the highest level.

11/03013 Energy-saving decomposition and power consumption forecast: the case of Liaoning province in China

He, Y. X. *et al. Energy Conversion and Management*, 2011, 52, (1), 340–348.

To achieve sustainable development of the society, the People's Republic of China (PRC) proposed in its 11th Five-Year Plan for National Economic and Social Development Program a shift in energy-saving target of decreasing energy intensity by 20% in 2010 compared with that of 2005. Liaoning province is one of the oldest industrial bases in China. Policymakers are often confronted with problems relating to adjustment in the development pattern as a means to secure steady economic growth. The power industry is a fundamental energy industry; it plays an important role in realizing of energy-saving targets. Based on the input–output model, this paper sets extensive, planning and 20% energy-saving scenarios in order to analyse energy-saving and power consumption situations for Liaoning by 2010. Through extensive simulations, the levels of energy-saving and power demand under different scenarios are obtained. Results from the analysis show that under the premises of adjusting the ratio of investment and consumption, optimizing products structure, and improving energy use efficiency, it is possible to achieve the proposed energy-saving target. Liaoning's power consumption can maintain a stable growth trend in the future. The percentage of electricity to the total energy use can also increase to 16% in 2010.

11/03014 Estimates of energy subsidies in China and impact of energy subsidy reform

Lin, B. Q. and Jiang, Z. *Energy Economics*, 2011, 33, (2), 273–283.

For a transitional economy such as China, some energy subsidies are reasonable, and sometimes even necessary for achieving social goals. However, with rising energy prices and environmental concerns, the authors see conflicts emerging between energy subsidies, energy demand/supply fundamentals and climate change considerations. Energy subsidies have important implications for sustainable development through their effects on energy use, efficiency and the choice of fuel source. This paper applies the price-gap approach to estimate China's energy subsidies. Results indicate that China's energy subsidies amounted to CNY356.73 billion in 2007, equivalent to 1.43% of GDP. Subsidies for oil products consumption are the largest, followed by subsidies for the electricity and coal sectors. Furthermore, a CGE model is used to analyse the economic impacts of energy subsidy reforms. The findings show that removing energy subsidies will result in a significant fall in energy demand and emissions, but will have negative impacts on macroeconomic variables. The authors conclude that offsetting policies could be adopted such that certain shares of these subsidies are reallocated to support other sustainable development measures, which could lead to reducing energy intensity and favouring the environment.

11/03015 Evaluation of the impact of the surrounding urban morphology on building energy consumption

Wong, N. H. *et al. Solar Energy*, 2011, 85, (1), 57–71.

Empirical models of minimum ($T_{\min}$), average (T_{avg}) and maximum ($T_{\max}$) air temperature for Singapore estate have been developed and validated based on a long-tem field measurement. There are three major urban elements, which influence the urban temperature at the local scale. Essentially, they are buildings, greenery and pavement. Other related parameters identified for the study, such as green plot ratio (GnPR), sky view factor (SVF), surrounding building density, the wall surface area, pavement area, albedo are also evaluated to give a better understanding on the likely impact of the modified urban morphology on energy consumption. The objective of this research is to assess and to compare how the air temperature variation of urban condition can affect the building energy consumption in tropical climate of Singapore. In order to achieve this goal, a series of numerical calculation and building simulation are utilized. A total of 32 cases, considering different urban morphologies, are identified and evaluated to give better a understanding on the implication of urban forms, with the reference to the effect of varying density, height and greenery density. The results show that GnPR, which related to the present of greenery, have the most significant impact on the energy consumption by reducing the temperature by up to 2 °C. The results also strongly indicate an energy saving of 4.5% if the urban elements are addressed effectively.

11/03016 India's energy security: a sample of business, government, civil society, and university perspectives

Bambawale, M. J. and Sovacool, B. K. *Energy Policy*, 2011, 39, (3), 1254–1264.

This article explores the concept of energy security perceived and understood by a sample of government, business, civil society, and university stakeholders in India. Based on a literature review, the authors hypothesize what energy experts suggest energy security is for India. The article then tests these hypotheses through the use of a survey completed by 172 Indian respondents. The article begins by describing its methodology before summarizing the results of the literature review to distil seven working hypotheses related to energy security in India. These hypotheses relate to (1) security of energy supply, (2) equitable access to energy services, (3) research and development of new energy technologies, (4) energy efficiency and conservation, (5) self-sufficiency and trade in energy fuels, (6) nuclear power, and (7) the energy–water nexus. It then tests these hypotheses with the survey instrument before concluding with implications for energy policy in India and beyond.

11/03017 Inequality across countries in energy intensities: an analysis of the role of energy transformation and final energy consumption

Duro, J. A. and Padilla, E. *Energy Economics*, 2011, 33, (3), 474–479.

This paper analyses the role of the energy transformation index and of final energy consumption per GDP unit in the disparities in energy intensity across countries. In that vein, the authors use a Theil decomposition approach to analyse global primary energy intensity inequality as well as inequality across different regions of the world and inequality within these regions. The paper first demonstrates the pre-eminence of divergence in final energy consumption per GDP unit in explaining global primary energy intensity inequality and its evolution during the 1971–2006 period. Secondly, it shows the lower (albeit non negligible) impact of the transformation index in global primary energy inequality. Thirdly, the relevance of regions as unit of analysis in studying cross-country energy intensity inequality and their explanatory factors is highlighted. And finally, how regions around the world differ as to the relevance of the energy transformation index in explaining primary energy intensity inequality.

11/03018 Institutionalized knowledge conflict in assessing the possible contributions of H_2 to a sustainable energy system for the Netherlands

Hisschemöller, M. and Bode, R. *International Journal of Hydrogen Energy*, 2011, 36, (1), 14–24.

This paper reports on a stakeholder dialogue project on the possible contribution of hydrogen to the Dutch energy transition. Dialogue methodology aims at articulating and exploring competing perspectives, including views that are in the margin of the energy policy subsystem. Three dialogue groups explored trajectories: 'hydrogen for transport', 'hydrogen for the built environment' and 'hydrogen in the existing natural gas grid'. The groups identified barriers and opportunities for the trajectories through back-casting and assessed its pros and cons as compared to a non-hydrogen alternative. Referees from abroad contributed to a confrontation workshop, where the groups exchanged and discussed their first findings. The dialogue reveals that stakeholders are strongly divided with respect to small-scale domestic as well as the concept of a flexible natural gas infrastructure. A conflict is found between knowledge claims that either support or challenge the *status quo*. This is referred to as institutionalized knowledge conflict.

11/03019 Inter-governmental institutions as promoters of energy policy diffusion in a federal setting

Strebel, F. *Energy Policy*, 2011, 39, (1), 467–476.

This article is about diffusion processes behind the innovation of sub-national energy policy measures in a federal system. Typically for the federal political system in Switzerland, the elements of the energy policy field are shaped by the principle of subsidiarity. The aim is that cantons promote innovative problem solutions and regionally adapted implementation. For this reason, policy differences between cantons are large and create a need for coordination. The author analyses the impact of inter-cantonal institutions on different innovations in the field of energy policy. The research question is approached with an event history analysis on three different innovative measures in the Swiss cantons from 1990 to 2007. A more comprehensive picture of diffusion in one policy field is drawn with this approach. The main contribution of this paper is the finding that intergovernmental institutions promote diffusion in one policy field only for measures with certain characteristics. The internal determinants are therefore not a sufficient explanation.

11/03020 Meeting U.S. passenger vehicle fuel economy standards in 2016 and beyond

Cheah, L. and Heywood, J. *Energy Policy*, 2011, 39, (1), 454–466.

New fuel economy standards require new US passenger vehicles to achieve at least 34.1 miles per gallon (MPG) on average by model year 2016, up from 28.8 MPG today. In this paper, the magnitude, combinations and timings of the changes required in US vehicles that are necessary in order to meet the new standards, as well as a target of doubling the fuel economy within the next two decades are explored. Scenarios of future vehicle characteristics and sales mix indicate that the 2016 mandate is aggressive, requiring significant changes starting from today. New vehicles must forgo horsepower improvements, become lighter, and a greater number will use advanced, more fuel-efficient powertrains, such as smaller turbocharged engines, hybrid-electric drives. Achieving a factor-of-two increase in fuel economy by 2030 is also challenging, but more feasible since the auto industry will have more lead time to respond. A discussion on the feasibility of meeting the new fuel economy mandate is included, considering vehicle production planning realities and challenges in deploying new vehicle technologies into the market.

11/03021 Nuclear energy option for energy security and sustainable development in India

Mallah, S. *Annals of Nuclear Energy*, 2011, 38, (2–3), 331–336.

India is facing great challenges in its economic development due to the impact on climate change. Energy is the important driver of economy. At present Indian energy sector is dominated by fossil fuel. Due to international pressure for green house gas reduction in atmosphere there is a need of clean energy supply for energy security and sustainable development. The nuclear energy is a sustainable solution in this context to overcome the environmental problem due to fossil fuel electricity generation. This paper examines the implications of penetration of nuclear energy in Indian power sector. Four scenarios, including base case scenario, have been developed using MARKAL energy modelling software for Indian power sector. The least-cost solution of energy mix has been measured. The result shows that more than 50% of the electricity market will be captured by nuclear energy in the year 2045. This ambitious goal can be expected to be achieved due to Indo-US nuclear deal. The advanced nuclear energy with conservation potential scenario shows that huge amounts of CO_2 can be reduced in the year 2045 with respect to the business as usual scenario.

11/03022 Roof-top solar energy potential under performance-based building energy codes: the case of Spain

Izquierdo, S. *et al. Solar Energy*, 2011, 85, (1), 208–213.

The quantification at regional level of the amount of energy (for thermal uses and for electricity) that can be generated by using solar systems in buildings is hindered by the availability of data for roof area estimation. The authors build on an existing geo-referenced method for determining available roof area for solar facilities in Spain to produce a quantitative picture of the likely limits of roof-top solar energy. The installation of solar hot water systems (SHWS) and photovoltaic systems (PV) is considered. After satisfying up to 70% (if possible) of the service hot water demand in every municipality, PV systems are installed in the remaining roof area. Results show that, applying this performance-based criterion, SHWS would contribute up to 1662 ktoe/y of primary energy (or 68.5% of the total thermal-energy demand for service hot water), while PV systems would provide 10 TW h/y of electricity (or 4.0% of the total electricity demand).

11/03023 Saturation, energy consumption, CO_2 emission and energy efficiency from urban and rural households appliances in Mexico

Rosas-Flores, J. A. *et al. Energy and Buildings*, 2011, 43, (1), 10–18.

Energy usage and energy efficiency are of increasing concern in Mexico, electricity generation principally depends upon fossil fuels. On one hand, the stocks of these fuels have been confirmed to be critically limited. On the other hand, in process of electricity generation by means of these fuels, a number of poisonous by-products adversely affect the conservation of natural eco-system. This paper focuses on estimation of energy consumption, energy savings, reduction of emissions of CO_2 for use of urban and rural household appliances in Mexico between 1996 and 2021. The analysis concentrates on six major energy end uses in the residential sector: refrigerators, air conditioners, washing machines, TV set, iron and heater. It is estimated that by 2021 there will be a cumulative saving of 22,605 GWh, as a result of the implementation of government programs on energy efficiency that represents a cumulative reduction of CO_2 emissions of 15,087 Tg CO_2. It means that Mexico can reduce in 5650 MW the generation capacity of national electricity system, which is to avoid burning 40.35 MM barrels of oil. The findings can be useful to policy makers as well as household appliances users.

11/03024 The causal relationship between electricity consumption and economic growth in a gaming and tourism center: the case of Macao SAR, the People's Republic of China

Lai, T. M. *et al. Energy*, 2011, 36, (2), 1134–1142.

A number of Asian cities decided to establish gaming and resort facilities in order to capitalize on the growing number of gamblers and their family members in Asia. In doing so, they expect to sustain economic growth but, on the other hand, will consume a considerable amount of energy. Nevertheless, the causal relationship between economic growth and electricity consumption in this type of service-oriented territories has never been investigated. Using the historical data obtained from the government of Macao SAR, electricity consumption and economic growth in terms of gross domestic product were co-integrated for the period of 1999 quarter 1–2008 quarter 4. Moreover, vector error correction (VEC) models indicated a lack of short-run relationships but showed that there was a long-run equilibrium relationship between electricity consumption and gross domestic product. The accuracy of VEC models was assessed by using the mean squared error and the mean absolute error. The error analysis shows that VEC models reproduced time series of gross domestic product and electricity consumption in different forms accurately.

11/03025 The challenge of energy poverty: Brazilian case study

Pereira, M. G. *et al. Energy Policy*, 2011, 39, (1), 167–175.

In recent years successive Brazilian governments have actively pursued economic and social policies aimed at reducing poverty and promoting social equality and inclusion. In the field of energy, this has meant introducing and implementing programs aimed at expanding the supply of safe and reliable energy to the poorest sectors of Brazilian society, including those living in remote rural areas. This paper draws attention on the findings of extensive field research to evaluate the impact of rural electrification on energy poverty in the context of government policies aimed at promoting energy equity. The authors re-examine the concept of an energy poverty line, seeking to fine tune its application to Brazilian social and economic realities, and then apply an analytical framework (Lorenz curve, gap poverty, gap quadratic, Gini coefficient and Sen index) to evaluate the effectiveness of recent efforts in Brazil to expand access to electricity. One of the main conclusions of this study is that is that rural electrification leads to a significant reduction of the energy poverty level and a consequent improvement in energy equity.

11/03026 The decline of the world's energy intensity

Goldemberg, J. and Prado, L. T. S. *Energy Policy*, 2011, 39, (3), 1802–1805.

Energy intensity of the total primary energy supply (TPES), total final energy consumption (TFC) and losses in the conversion from TPES to TFC were analysed for the world, OECD countries and rest of the world (ROW) countries. Losses increased significantly for all groups of countries due to the increase of electricity production from coal in the period studied (1971–2008). Electricity share final consumption almost doubled, increasing from 8.8% to 17.2% in the period studied. However the energy intensity of losses remained practically constant, which reflects the fact that the efficiency of electricity generation from coal (the main source of electricity) remained practically constant in that period. Despite the attractiveness of end-use devices running on electricity such as computers, which is typical of modern societies, the CO_2 emissions are bound to increase unless coal is replaced by less carbon emitting sources such as natural gas, renewables and nuclear energy.

11/03027 The development of the German energy market until 2030 – a critical survey of selected scenarios

Keles, D. *et al. Energy Policy*, 2011, 39, (2), 812–825.

Many scenarios have been generated over the last years analysing the international energy market. The variety of these scenarios is manifold, as they are generated by different institutions using different methodological approaches and different framework assumptions. However, these scenarios can roughly be classified into three main groups: 'moderate', 'climate protection' and 'resource scarcity and high fossil fuel prices'. Analysing the German energy market makes a fourth scenario group necessary, which considers the possible revision of the decided nuclear energy phase out. Most of the existing scenarios developed by different institutions can be allocated into one of these groups. A representative scenario for each group has been selected to illustrate the development of the energy sector until 2030. Contrary to the worldwide primary energy demand (PED), the German PED decreases in each scenario, even though the drop differs strongly throughout the scenarios. On the other hand the structure of the PED in 2030 varies strongly for each scenario, especially regarding the share of fossil energy sources. However, a common robust result can be observed throughout all scenarios, namely the high increase in the share of the renewable energy resources, although the scenario generation processes are not always robust.

11/03028 The UK offshore wind power programme: a sea-change in UK energy policy?

Toke, D. *Energy Policy*, 2011, 39, (2), 526–534.

The British offshore windfarm programme presages the emergence of Britain as more of a leader than a laggard in renewables, the latter being the status it has hitherto endured in comparison to countries such as Denmark, Germany and Spain. Britain looks increasingly likely to exceed 20% of electricity being supplied from renewable energy by 2020, provided there continues to be adequate financial incentives for renewable energy. This turnaround is associated with increased British concerns about energy dependence on imported natural gas as well as pressure from EU legislation. However there are many planning pressures that countervail the drive for offshore wind power. British planning policy on offshore wind is distinctive (compared to other EU states) for its pragmatic, 'criteria based', approach that appears to favour offshore wind power development. The extent of the British offshore wind power programme is likely to depend heavily on consumer reactions to price increases caused by the offshore wind power programme.

11/03029 UK energy policy ambition and UK energy modelling – fit for purpose?

Strachan, N. *Energy Policy*, 2011, 39, (3), 1037–1040.

Aiming to lead among other G20 countries, the UK government has classified the twin energy policy priorities of decarbonization and security of supply as a 'centennial challenge'. This viewpoint discusses the UK's capacity for energy modelling and scenario building as a critical underpinning of iterative decision making to meet these policy ambitions. From a nadir, over the last decade UK modelling expertise has been steadily built up. However extreme challenges remain in the level and consistency of funding of core model teams – critical to ensure a full scope of energy model types and hence insights, and in developing new state-of-the-art models to address evolving uncertainties. Meeting this challenge will facilitate a broad scope of types and geographical scale of UK's analytical tools to responsively deliver the evidence base for a range of public and private sector decision makers, and ensure that the UK contributes to global efforts to advance the field of energy-economic modelling.

Energy conservation

11/03030 A realistic approach for reduction of energy losses in low voltage distribution network

Chitra, R. and Neelaveni, R. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (3), 377–384.

This paper proposes reduction of energy losses in low voltage distribution network using LabVIEW as a simulation tool. It suggests a methodology for balancing load in all three phases by predicting and controlling current unbalance in three-phase distribution systems by node reconfiguration solution for typical Indian scenario. A fuzzy logic-based load balancing technique along with optimization-oriented expert system for implementing the load changing decision is proposed. The input is the total phase current for each of the three phases. The average unbalance per phase is calculated and checked against threshold value. If the average unbalance per phase is below threshold value, the system is balanced. Otherwise, it goes for the fuzzy logic based load balancing. The output from the fuzzy logic based load balancing is the value of load to be changed for each phase. A negative value indicates that the specific phase is less loaded and should receive the load, while a positive value indicates that the specific phase is surplus load and should release that amount of load. The load change configuration is the input to the expert system which suggests optimal shifting of the specific number of load points, i.e. the consumers.

11/03031 A study on optimum insulation thickness in walls and energy savings in Tunisian buildings based on analytical calculation of cooling and heating transmission loads

Daouas, N. *Applied Energy*, 2011, 88, (1), 156–164.

In the Tunisian climate, both heating in winter and cooling in summer are required to reach comfort levels. Due to the significant increase in building energy consumption, insulation of external walls is recently applied with a thickness typically ranging between 4 and 5 cm regardless of structure and orientation of walls and of economic parameters. In the present study, optimum insulation thickness, energy saving and payback period are calculated for a typical wall structure based on both cooling and heating loads. Yearly transmission loads are rigorously estimated using an analytical method based on complex finite Fourier transform (CFFT). Considering different wall orientations, the west- and east-facing walls are the least favourite in the cooling season, whereas the north-facing wall is the least favourite in the heating season. A life-cycle cost analysis over a building lifetime of 30 years shows that the south orientation is the most economical with an optimum insulation thickness of 10.1 cm, 71.33% of energy savings and a payback period of 3.29 years. It is noted that wall orientation has a small effect on optimum insulation thickness, but a more significant effect on energy savings which reach a maximum value of 23.78 TND/m^2 in the case of east facing wall. A sensitivity analysis shows that economic parameters, such as insulation cost, energy cost, inflation and discount rates and building lifetime, have a noticeable effect on optimum insulation and energy savings. Comparison of the present study with the degree-days model is also performed.

11/03032 Analyzing the effect of the longwave emissivity and solar reflectance of building envelopes on energy-saving in buildings in various climates

Shi, Z. and Zhang, X. *Solar Energy*, 2011, 85, (1), 28–37.

A dynamic computer simulation is carried out in the climates of 35 cities distributed around the world. The variation of the annual air-conditioning energy loads due to changes in the longwave emissivity and the solar reflectance of the building envelopes is studied to find the most appropriate exterior building finishes in various climates (including a tropical climate, a subtropical climate, a mountain plateau climate, a frigid-temperate climate and a temperate climate). Both the longwave emissivity and the solar reflectance are set from 0.1 to 0.9 with an interval of 0.1 in the simulation. The annual air-conditioning energy loads trends of each city are listed in a chart. The results show that both the longwave emissivity and the solar reflectance of building envelopes play significant roles in energy-saving for buildings. In tropical climates, the optical parameters of the building exterior surface affect the building energy-saving most significantly. In the mountain plateau climates and the subarctic climates, the impacts on energy-saving in buildings due to changes in the longwave emissivity and the solar reflectance are still considerable, but in the temperate continental climates and the temperate maritime climates, only limited effects are seen.

11/03033 Application of the modified Tobin's *q* to an uncertain energy-saving project with the real options concept

Lin, T. T. and Huang, H.-L. *Energy Policy*, 2011, 39, (1), 408–420.

This paper is to develop a modified Tobin's *q* evaluation method which successfully combines the evaluation criteria of the traditional Tobin's *q* and the real options. This study provides flexible thinking for decision making criteria. That is, it clearly provides decision-makers with a reference in choosing enter or exit strategies, such as quantitative indicators references. The proposed model introduces two variables stochastic process in continuous time and explores the impact of the occurrence of unexpected events on the project value, so that, it can more authentically response to the project value. The studied issue deals with the firms that have not established energy-saving equipment yet. It attempts to figure out the optimal timing to adopt an energy-saving investment project when it is beneficial and the optimal timing to terminate it when the continuous operation of that business is unprofitable. The future discounted benefit–cost ratio, Q, follows the geometric Brownian motion with the Poisson jump process and the replacement of investment equipment. Except for the evaluation of energy-saving equipment investment project, the proposed model can be applied to other related project evaluation issues, such as energy-saving, CO_2 emission reduction, or general investment projects.

11/03034 Comparison of annual energy performances with different ventilation methods for cooling

Lin, Z. *et al. Energy and Buildings*, 2011, 43, (1), 130–136.

Stratum ventilation has been proposed to cope for elevated indoor temperatures recommended by governments in east Asia. TRNSYS is used for computation of the space cooling load and system energy consumption. Typical configurations of an office, a classroom and a retail shop in Hong Kong are investigated. Compared with mixing ventilation and displacement ventilation, stratum ventilation derives its energy saving potential largely from the following three factors: the reduction in ventilation and transmission loads and increased COP of chillers. The year-round energy saving is found to be substantial at 25% and 44% at least when compared with displacement ventilation and mixing ventilation, respectively.

11/03035 Energy and exergy efficiencies in the Chinese transportation sector, 1980–2009

Zhang, M. *et al. Energy*, 2011, 36, (2), 770–776.

This paper analysed energy and exergy efficiencies in the Chinese transportation sector. Historical data were used to investigate the development of efficiencies from 1980 to 2009. First, energy consumption values in petajoules were calculated for nine transportation modes of five transportation sub-sectors. Then, the weighted energy and exergy efficiencies for each transportation mode, calculated by multiplying weighting factors with efficiency values of that mode, were summed up to calculate the weighted mean overall efficiencies for a particular year. It was found that: (1) in 2009, the energy consumed in transportation sector was 12,179.80 PJ, whereas that was 589.25 PJ in 1980; (2) highways transport was the biggest energy consumer, which consumed 82.0% of total transport energy consumption in 2009; (3) up to 2009, the oil consumed by transportation accounted for 75.1% of that in the whole country, which is more than the net oil import; (4) the average overall energy and exergy efficiencies are found to be 21.22% and 19.95%, respectively and (5) a comparison with other countries showed that energy and exergy efficiencies of the Chinese transportation sector are slightly lower than those of Jordan, Malaysia, Saudi Arabia and Norway, and higher than that incurred in Turkey.

11/03036 Energy conservation measures in an institutional building in sub-tropical climate in Australia

Rahman, M. M. *et al. Applied Energy*, 2010, 87, (10), 2994–3004.

In this study, various energy conservation measures (ECMs) on heating, ventilating and air conditioning (HVAC) and lighting systems for a four-storied institutional building in sub-tropical (hot and humid climate) Queensland, Australia are evaluated using the simulation software called DesignBuilder (DB). Base case scenarios of energy consumption profiles of existing systems are analysed and simulated first then, the simulated results are verified by on-site measured data. Three categories of ECMs, namely major investment ECMs (variable air volume systems against constant air volume; and low coefficient of performance chillers against high coefficient of performance chillers); minor investment ECMs (photoelectric dimming control system against general lighting, and double glazed low emittance windows against single-glazed windows) and zero investment ECMs (reset heating and cooling set point temperatures) are evaluated. It is found that the building considered in this study can save up to 41.87% energy without compromising occupancies thermal comfort by implementing the above mentioned ECMs into the existing system.

11/03037 Energy savings assessment for digital-to-analog converter boxes

Cheung, H. Y. *et al. Energy Policy*, 2011, 39, (3), 1312–1317.

The digital television converter box coupon program was administered by the US government to subsidize purchases of digital-to-analogue converter boxes, with up to two $40 coupons for each eligible household. In order to qualify as coupon eligible converter boxes (CECBs), these devices had to meet a number of minimum performance specifications, including energy efficiency standards. The Energy Star program also established voluntary energy efficiency specifications that are more stringent than the CECB requirements. This study measured the power and energy consumptions for a sample of 12 CECBs (including six Energy Star labelled models) in-use in homes and estimated aggregate energy savings produced by the energy efficiency policies. Based on the 35 million coupons redeemed through the end of the program, this analysis indicates that between 2500 and 3700 GWh per year are saved as a result of the energy efficiency policies implemented on digital-to-analogue converter boxes. The energy savings generated are equivalent to the annual electricity use of 280,000 average US homes.

11/03038 Integrated energy strategy for the sustainable development of China

Ma, L. *et al. Energy*, 2011, 36, (2), 1143–1154.

This paper proposes an integrated energy strategy based on a systems approach to address the energy challenges and energy dilemma in China. First, a review of existing approaches to energy planning and strategic management is provided, followed by a discussion on the major relationships among energy, economical, environmental and societal systems. Next, a conceptual system model is presented with alternative solutions and clarified corresponding concepts. In conclusion, it is suggested that China should enhance strategic planning and regulation from a life cycle viewpoint of the whole society, prioritize energy saving, continuously improve incumbent energy, and rationally develop alternative energy.

11/03039 Intelligent control system for reconciliation of the energy savings with comfort in buildings using soft computing techniques

Dounis, A. I. *et al. Energy and Buildings*, 2011, 43, (1), 66–74.

This paper presents a novel intelligent coordinator control system based on hierarchical structure. The presented structure consists of one coordinator and five fuzzy logic controllers. The intelligent coordinator architecture contains uses a master and a slave agent. The master agent is an economy behaviour fuzzy system and the slave agent consists of two fuzzy negotiation machines (FNMs) and one decision logic unit. Type-1 FS models are chosen to characterize the concepts of thermal comfort, illuminance and carbon dioxide concentration. The word 'comfort' is represented by a 3D fuzzy set in fuzzy cube. Using the symmetric fuzzy equality measure, the membership grade of the 3D fuzzy comfort set can be quantified. The structure of a fuzzy controller-agent (FCA) is presented and the tuning of parameters of the FLC by genetic algorithms (GAs) proposed. The simulation results show that the proposed intelligent control system successfully manages the users' preferences for thermal and illuminance comfort, indoor air quality and the energy conservation.

11/03040 Investigation of the thermal resistance of timber attic spaces with reflective foil and bulk insulation, heat flow up

Belusko, M. *et al. Applied Energy*, 2011, 88, (1), 127–137.

An experimental investigation was undertaken in which the thermal resistance for the heat flow through a typical timber-framed pitched roofing system was measured under outdoor conditions for heat flow up. The measured thermal resistance of low resistance systems such as an uninsulated attic space and a reflective attic space compared well with published data. However, with higher thermal resistance systems containing bulk insulation within the timber frame, the measured result for a typical installation was as low as 50% of the thermal resistance determined considering two-dimensional thermal bridging using the parallel path method. This result was attributed to three-dimensional heat flow and insulation installation defects, resulting from the design and construction method used. Translating these results to a typical house with a 200 m^2 floor area, the overall thermal resistance of the roof was at least 23% lower than the overall calculated thermal resistance including two-dimensional thermal bridging. When a continuous layer of bulk insulation was applied to the roofing system, the measured values were in agreement with calculated resistances representing a more reliable solution.

11/03041 Investigation on the effectiveness of various methods of information dissemination aiming at a change of occupant behaviour related to thermal comfort and exergy consumption

Schweiker, M. and Shukuya, M. *Energy Policy*, 2011, 39, (1), 395–407.

These days the number of projects trying to urge a change in the occupant's behaviour towards a sustainable one is increasing. However, still less is known about the effect of such measures. This paper describes the findings of two investigations, a field measurement and an Internet-based survey, both including the dissemination of information about strategies for a high level of comfort without much energy usage. The focus was on the ability to quantify the effect of such measures on the heating and cooling behaviour. As a result, those who participated in a workshop were more likely to change their behaviour than those who received an information brochure only; whether this was due to the method employed or the type of participants could not be ascertained. However, the workshop participants reduced their cooling device usage by up to 16%. The concept of exergy was used to show how this reduction affects the exergy consumption of the cooling device, because it enables us to consider the qualitative aspect of energy as a quantity to be calculated. This showed that the exergy consumed by the workshop group was reduced by up to 20% comparing their behaviour before and after the information dissemination.

11/03042 On subcooler design for integrated two-temperature supermarket refrigeration system

Yang, L. and Zhang, C.-L. *Energy and Buildings*, 2011, 43, (1), 224–231.

The energy saving opportunity of supermarket refrigeration systems using subcooler between the medium-temperature refrigeration system and the low-temperature refrigeration system has been identified in the previous work. This paper presents a model-based comprehensive analysis on the subcooler design. The optimal subcooling control is discussed as well. With optimal subcooler size and subcooling control, the maximum energy savings of integrated two-temperature supermarket refrigeration system using R404A or R134a as working fluid can achieve 27% or 20%, respectively. The load ratio of MT to LT system and the operating conditions have considerable impact on the energy savings.

11/03043 Optimisation based design of a district energy system for an eco-town in the United Kingdom

Weber, C. and Shah, N. *Energy*, 2011, 36, (2), 1292–1308.

The reduction of CO_2 emissions linked with human activities (mainly energy services and transport), together with the increased use of renewable energies, remain high priorities on various political agendas.

However, considering the increased consumption of energy services (especially electricity), and the stochastic nature of some of the most promising renewable energies (wind for instance), the challenge is to find the optimal mix of technologies that will provide the energy services, without increasing the CO_2 emissions, but nonetheless ensuring reliability of supply. The focus of this paper is to present the DESDOP tool, based on mixed integer linear optimization techniques, that helps giving insight in the optimal mix of technologies that will simultaneously help decrease the emissions while at the same time guarantee resilience of supply. The results show that while it is not yet possible to avoid electricity from the grid completely (hence nuclear or fossil fuel), CO_2 reductions up to 20%, at no extra costs compared to the business-as-usual case, are easily achievable.

11/03044 Optimization and design of energy transport system for solar cooking application

Prasanna, U. R. and Umanand, L. *Applied Energy*, 2011, 88, (1), 242–251.

This paper proposes a hybrid solar cooking system where the solar energy is transported to the kitchen. The thermal energy source is used to supplement the liquefied petroleum gas (LPG) that is in common use in kitchens. Solar energy is transferred to the kitchen by means of a circulating fluid. Energy collected from sun is maximized by changing the flow rate dynamically. This paper proposes a concept of maximum power point tracking (MPPT) for the solar thermal collector. The diameter of the pipe is selected to optimize the overall energy transfer. Design and sizing of different components of the system are explained. Concept of MPPT is validated with simulation and experimental results.

11/03045 Optimization of energy and manpower requirements in Nigerian bakeries

Ekechukwu, O. V. *et al. Energy Conversion and Management*, 2011, 52, (1), 564–568.

A study on energy and manpower requirements for the bakery industry in Nigeria was carried out, covering 90 bakeries representing 75% of total registered bakeries in Onitsha city. Analysis of the energy and manpower related time series data, using engineering and statistical tools, resulted in the development of empirical model for the estimation of capacity, manpower and energy requirements in the bakery industry. This empirical model can be used for the design of a new bakery or expansion of existing one. The conditions for optimum inventory and design were determined through this optimization and the results were compared with existing system. The study revealed a huge capital investment which amounts to 5.6 billion Naira annually, a correlation between capacity of the bakery plants and resource usage (manpower, raw materials and energy use), and jobs creation potentials for 960 persons for Onitsha city alone. Diesel contributes 66.75% of total heating energy need, followed by firewood, 22.57% and petrol, 10.68%. Application of optimization techniques could result in 61% savings in inventory costs and cut in energy by about 7.4% with overall cost reduction of 8%.

11/03046 Optimizing energy consumption of a water-loop variable-speed heat pump system

Yuan, S. and Grabon, M. *Applied Thermal Engineering*, 2011, 31, (5), 894–901.

Water-loop heat pump (WLHP) systems have been widely used for decades. The most appealing feature of WLHP is its capability of handling simultaneous heating and cooling demands in a building and recovering heat generated from zones in cooling. The typical heat sink and source are cooling tower and boiler. WHLPs discussed in this paper are equipped with a variable-speed compressor; the cooling tower comes with one variable-speed fan; and the boiler has a continuously-adjustable capacity. This paper analyses how the energy efficiency of individual component responds to variations in loop water temperature; demonstrates that there exists a unique loop-water temperature that minimizes overall energy consumption given a certain building load; proposes a practical strategy to find the optimal temperature in a real-time manner.

11/03047 Primary energy implications of end-use energy efficiency measures in district heated buildings

Gustavsson, L. *et al. Energy and Buildings*, 2011, 43, (1), 38–48.

This study explores the effects of end-use energy efficiency measures on different district heat production systems with combined heat and power (CHP) plants for base load production and heat-only boilers for peak and medium load productions. Four minimum cost district heat production systems were modelled based on four environmental taxation scenarios, plus a reference district heat system used in Östersund, Sweden. Primary energy use and the cost of district heat production for each system were analysed, as well as the primary energy implications of end-use energy efficiency measures applied to a case-study apartment building, taking into account the reduced district heat demand, reduced cogenerated electricity and increased electricity use due to ventilation heat recovery. It was found that district heat production cost in optimally designed production systems is not sensitive to environmental taxation. The primary energy savings of end-use energy efficiency measures depend on the characteristics of the district heat production system and the type of end-use energy efficiency measures. Energy efficiency measures that reduce more of peak load than base load production give higher primary energy savings, because the primary energy efficiency is higher for CHP plants than for boilers. This study shows the importance of analysing both the demand and supply sides as well as their interaction in order to minimize the primary energy use of district heated buildings.

11/03048 Reduce energy use and greenhouse gas emissions from global dairy processing facilities

Xu, T. and Flapper, J. *Energy Policy*, 2011, 39, (1), 234–247.

Butter, concentrated milk and milk powder products use approximately 15% of the world's annual raw milk production. Similar to cheese and liquid milk, dairy processing of these products can be energy intensive. In this paper, the authors analysed the production and energy data compiled through extensive literature reviews on butter, concentrated milk, milk and whey powder processing across various countries and plants. Magnitudes of national final and primary specific energy consumption (SEC) exhibited large variations across dairy products; in addition, the final SEC of individual plants and products exhibited significant variations within a country and between countries. Furthermore, the authors quantified national energy intensity indicators (EIIs) accounting for dairy product mixes and technological advancement. The significant variations of SEC and EII values indicate a high degree of likelihood that there is significant potential for energy savings in the global dairy processing industry. Based on the study samples, the authors estimate potential energy savings for dairy processing industry in selected countries, and estimates annual reduction of 9–14 million tonnes carbon-equivalent could be achieved if measures are implemented to lower SEC values by 50–80% in half of global dairy plants. The paper calls for publication of more energy data from the dairy processing industry.

11/03049 The baseline in bottom-up energy efficiency and saving calculations – a concept for its formalisation and a discussion of relevant options

Reichl, J. and Kollmann, A. *Applied Energy*, 2011, 88, (2), 422–431.

One of the central variables in bottom-up energy efficiency and saving calculations is the energy consumption baseline. In the evaluation of energy efficiency measures, developing this baseline is a challenging task and may involve serious problems, especially if the energy service of the analysed subject has changed while the energy efficiency measure was being implemented. A formalized concept of the process of developing the baseline is presented that is flexible enough to deal with various difficulties, such as changes in the levels of the energy services involved. The most relevant options for deriving the necessary variables are also discussed.

11/03050 The challenge to UK energy policy: an ageing population perspective on energy saving measures and consumption

Hamza, N. and Gilroy, R. *Energy Policy*, 2011, 39, (2), 782–789.

With a focus on the residential sector, this paper explores the likelihood of the UK government meeting its energy targets. The paper contends that energy policy needs to take into account the interplay of four major factors: an ageing population of increasing diversity; a cultural inclination for older housing much of which is thermally inefficient; levels of fuel poverty; and the inexorable rise of consumer spending on leisure related services and goods. Decisions made by older households (both the poorer and the better off) may be critical to the success of energy policy. Among the better off the changing expectations of the baby boomers, with their predilection for consumption and travel, may have particular impact. The paper concludes that much of the reduction in carbon footprint made by older people's choices in heating and insulation may be offset, not only by increasing domestic thermal comfort, but also potentially by increasing consumables in the home and other consumer lifestyle choices. What could be achieved at best, may be a shift in energy mix.

11/03051 Thermal energy savings in buildings with PCM-enhanced envelope: influence of occupancy pattern and ventilation

Diaconu, B. M. *et al. Energy and Buildings*, 2011, 43, (1), 101–107.

Integration of building materials incorporating PCMs into the building envelope can result in increased efficiency of the built environment. A PCM-enhanced wall system is proposed in this paper and a simplified model for the heat exchange between the indoor environment and ambient was developed. The objective of the study was to assess the effect of occupancy pattern and ventilation on the energy savings potential of the wall system. It was found that (1) the occupancy pattern influences the value of the PCM melting point for which maximum energy savings value was reached and (2) the ventilation and its pattern reduces the relative value of the energy savings.

11/03052 Three-dimensional non-isothermal modeling of carbon monoxide poisoning in high temperature proton exchange membrane fuel cells with phosphoric acid doped polybenzimidazole membranes

Jiao, K. *et al. Fuel*, 2011, 90, (2), 568–582.

The performance of proton exchange membrane fuel cell (PEMFC) degrades when carbon monoxide (CO) is present in the supplied fuel, which is referred to as CO poisoning. Even though the high-temperature PEMFC (HT-PEMFC) with a typical operating temperature range from 100 to 200 °C features higher CO tolerance than the conventional PEMFC operating at lower than 100 °C, the performance degradation of HT-PEMFC is still significant with high CO concentrations (e.g. $\geq$0.5% CO by volume at 130 °C) in the supplied fuel. In this study, a CO poisoning model is developed for HT-PEMFCs with phosphoric acid doped polybenzimidazole (PBI) membranes. The present three-dimensional non-isothermal model compares well with published experimental data at various operating temperatures and CO concentrations in the supplied fuel. It is found that the CO adsorption/desorption processes follow Langmuir kinetics in HT-PEMFCs instead of the well-known Temkin kinetics in conventional PEMFCs. The results indicate that a HT-PEMFC can operate with sufficiently good performance at 130 °C or higher with hydrogen gas produced by methanol reforming with selective oxidation process, and at 160 °C or higher even without the selective oxidation process. At high current densities, it is also observed that severe performance degradation due to CO poisoning only occurs if the volume averaged hydrogen coverage is lower than 0.1 in the anode catalyst layer.

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11/03053 An investigation of zincite from spent anodic portions of alkaline batteries: an industrial mineral approach for evaluating stock material for recycling potential

Barrett, H. A. *et al. Journal of Power Sources*, 2011, 196, (1), 508–513.

The mineralogy of anodic portions of spent alkaline batteries from a leading brand (Duracell) that had been equilibrated in ambient air for approximately 4 months was investigated to determine if material generated from this low energy process may be suitable stock material for recycling. Powder X-ray diffraction (XRD) identified the bulk of the ambient air oxidized anodic material as zincite (ZnO). Scanning electron microscopy investigation indicates a variety of textures of zincite are present with euhedral hexagonal prisms being the most common crystal form. Energy dispersive spectroscopy (EDS) analysis indicates that there are no minor amounts of Mn within the zincite. Transmission electron microscopy investigation indicates a variety of textures exist in the $<2\,\mu$m size fraction including near euhedral prismatic crystals, crystals with step-fashion terminations and indentations, heavily corroded zincite and near amorphous aggregates of anastomozing zinc oxide. Impurities in the $<2\,\mu$m size fraction include minor amounts of unidentified mixed sulfate materials and are interpreted as dominantly occurring as thin coatings on zincite particles. Discrete submicrometer-sized spherical and rhomboid particles of Zn–Mn oxides are also common impurities in the $<2\,\mu$m size fraction but occurr at abundance of <1% by volume.

11/03054 Continuous transesterification of biodiesel in a helicoidal reactor using recycled oil

Avellaneda, F. and Salvadó, J. *Fuel Processing Technology*, 2011, 92, (1), 83–91.

A problem with using biodiesel is the high cost of oils made from oleaginous crops. For this reason, various raw materials have been analysed with a view to reducing production costs and obtaining a product that can compete with the price of petrodiesel. Recycled oil is one of the most promising alternatives in the production of biodiesel because not only is the cheapest raw material but it also avoids the expense of treating the oil as a residue. Another way to reduce costs is to make the process more economical. Conventional technology uses sodium hydroxide as the basic catalyst and large-scale batch reactors, whose mechanical agitation requires high energy consumption due to residence times of at least 60 min and temperatures of 60 °C. In this paper the authors use a recycled pretreated oil to compare conventional transesterification with continuous transesterification in a tubular reactor. In this reactor the reactants (oil, methanol and sodium hydroxide) flow through a helicoidal tube submerged in a heating bath at 60 °C. The reactor has five outlets distributed non-uniformly to enable samples to be taken at different reaction times. This is to reduce the reaction time and avoid the need for mechanical agitation. With the aim of improving the quality of the biodiesel obtained, the authors varied the helicoidal system by incorporating a static micromixer and supplying energy in the form of ultrasound from the heating bath. This reactor produced biodiesel and glycerine at compositions roughly equal to those obtained in the batch process (89% FAME content at 75 min) but did so continuously (2.5 mL/min) and just 13 min after the reactants were integrated in a single line using a T device. Both the oil and the biodiesel were characterized and analysed in accordance with European standard UNE EN14214 for biodiesel.

11/03055 Experimental analysis of an air-to-air heat recovery unit for balanced ventilation systems in residential buildings

Fernández-Seara, J. *et al. Energy Conversion and Management*, 2011, 52, (1), 635–640.

This paper deals with the experimental analysis of an air-to-air heat recovery unit equipped with a sensible polymer plate heat exchanger (PHE) for balanced ventilation systems in residential buildings. The PHE is arranged in parallel triangular ducts. An experimental facility was designed to reproduce the typical outdoor and exhaust air conditions with regard to temperature and humidity. The unit was tested under balanced operation conditions, as commonly used in practice. A set of tests was conducted under the reference operating conditions to evaluate the PHE performance. Afterwards, an experimental parametric analysis was conducted to investigate the influence of changing the operating conditions on the PHE performance. Experiments were carried out varying the inlet fresh air temperature, the exhaust air relative humidity and the air flow rate. The experimental results are shown and discussed in this paper.

11/03056 Experimental investigation on heat recovery from diesel engine exhaust using finned shell and tube heat exchanger and thermal storage system

Pandiyarajan, V. *et al. Applied Energy*, 2011, 88, (1), 77–87.

The exhaust gas from an internal combustion engine carries away about 30% of the heat of combustion. The energy available in the exit stream of many energy conversion devices goes as waste, if not utilized properly. The major technical constraint that prevents successful implementation of waste heat recovery is due to its intermittent and time mismatched demand and availability of energy. In the present work, a shell and finned tube heat exchanger integrated with an internal combustion engine setup to extract heat from the exhaust gas and a thermal energy storage tank used to store the excess energy available is investigated in detail. A combined sensible and latent heat storage system is designed, fabricated and tested for thermal energy storage using cylindrical phase change material capsules. The performance of the engine with and without heat exchanger is evaluated. It is found that nearly 10–15% of fuel power is stored as heat in the combined storage system, which is available at reasonably higher temperature for suitable application. The performance parameters pertaining to the heat exchanger and the storage tank such as amount of heat recovered, heat lost, charging rate, charging efficiency and percentage energy saved are evaluated and reported in this paper.

11/03057 Fundamental experiment of pumpless Rankine-type cycle for low-temperature heat recovery

Yamada, N. *et al. Energy*, 2011, 36, (2), 1010–1017.

This paper proposes a new pumpless Rankine-type cycle for power generation from low-temperature heat sources. The new cycle mainly consists of an expander, two heat exchangers, and switching valves for the expander and heat exchangers. Instead of using a working fluid pump, the switching valves method (SVM) is employed to control the cycle. The SVM makes each heat exchanger switch between functioning as an evaporator and functioning as a condenser. In this arrangement, the working fluid flows back and forth between the two heat exchangers without a working fluid pump. Therefore, the new cycle does not involve problems caused by a pump. In the first basic experiment carried out to clarify the feasibility of the proposed cycle, the function of the expander was emulated by using an expansion nozzle. HFC245fa was used as the working fluid. The experimental results confirm that the proposed cycle works and that it has the potential to produce power. Fundamental time-varying characteristics of the proposed cycle are also shown and discussed.

11/03058 How can the heat transfer correlations for finned-tubes influence the numerical simulation of the dynamic behavior of a heat recovery steam generator?

Walter, H. and Hofmann, R. *Applied Thermal Engineering*, 2011, 31, (4), 405–417.

This paper presents the results of a theoretical investigation on the influence of different heat transfer correlations for finned-tubes to the dynamic behaviour of a heat recovery steam generator (HRSG). The investigation was done for a vertical type natural circulation HRSG with three pressure stages under hot start-up and shutdown conditions. For the calculation of the flue gas-side heat transfer coefficient the well known correlations for segmented finned-tubes according to Schmidt, VDI and ESCOA (traditional and revised) as well as a new correlation, which was developed at the Institute for Energy Systems and Thermodynamics, are used. The simulation results show a good agreement in the overall behaviour of the boiler between the different correlations. But there are still some important differences found in the detail analysis of the boiler behaviour.

11/03059 Integrating olive grove maintenance and energy biomass recovery with a single-pass pruning and harvesting machine

Spinelli, R. *et al. Biomass and Bioenergy*, 2011, 35, (2), 808–813.

In Italy, olive tree groves may offer up to a million tonnes of dry biomass per year as pruning residue. Searching for a cost-effective way to tap this potential, the authors tested a new machine, capable of recovering pruning residue at the same time as pruning. The pre-commercial prototype was tested on four different plots and compared to a simpler tractor-base mechanical pruning unit. The authors conducted detailed time-studies in order to determine machine productivity and residue recovery cost. The integrated machine can treat between 0.2 and 0.6 ha h^{-1}, producing between 0.33 and 1.03 tonnes of fresh residue $hour^{-1}$. Its integrated residue recovery function does not slow the pruning, which actually proceeds faster than with the tractor-base unit, due to the more efficient multiple-disc cutting bar. The marginal cost of residue recovery is around €40–45 per fresh tonne. However, the new machine must not be considered just as a biomass harvester, but rather as a mechanical pruning unit with an integrated biomass recovery function. Its main benefit derives from the capacity of performing a very effective mechanical pruning, and the residue recovery function is a secondary benefit yet unavailable on standard pruning machines. Its deployment must be seen in the context of a general effort to modernize olive grove management and to develop an integrated biomass production system, rather than as a further attempt to build a specialized biomass supply chain.

11/03060 Pyrolysis–gasification of agriculture biomass wastes for hydrogen production

Isha, R. and Williams, P. T. *Journal of the Energy Institute*, 2011, 84, (2), 80–87.

This study considered the influence of biomass composition, temperature, steam/biomass mole ratio and affect of CO_2 absorbent on the pyrolysis–gasification of different biomass wastes. The biomass samples, i.e. palm oil fibre, palm oil shell, corncob and coconut shell, were pyrolysed–gasified in a stainless-steel fixed-bed reactor from 600 to 1200 K. Experiments were undertaken using CaO as the CO_2 absorbent. The results showed that H_2 and char production were related to the biomass composition. It was found that the palm oil fibre produced the highest H_2, and the palm oil shell produced the largest amount of char. At higher gasification temperatures, more H_2, CO and CH_4 were formed, but the char production reduced at the same operating conditions. In addition, the addition of steam significantly promoted H_2 and CO production and also reduced the solid char product. The presence of steam improved the H_2 production at high temperature via water gas shift, Boudouard and reforming reactions. Furthermore, H_2 production also increased as CO_2 was removed from the system using CaO as a CO_2 absorbent. Although CaO is a good CO_2 absorbent, it was subject to physical deterioration caused by water and ash from the biomass. It was shown that an optimum H_2 concentration was obtained at >1000 K, 1 bar and steam/biomass mole ratio equal to 1 with *in situ* CO_2 removal for the palm oil fibre.

11/03061 Waste management, waste resource facilities and waste conversion processes

Demirbas, A. *et al. Energy Conversion and Management*, 2011, 52, (2), 1280–1287.

In this study, waste management concept, waste management system, biomass and bio-waste resources, waste classification, and waste management methods have been reviewed. Waste management is the collection, transport, processing, recycling or disposal, and monitoring of waste materials. A typical waste management system comprises collection, transportation, pre-treatment, processing, and final abatement of residues. The waste management system consists of the whole set of activities related to handling, treating, disposing or recycling the waste materials. General classification of wastes is difficult. Some of the most common sources of wastes are as follows: domestic wastes, commercial wastes, ashes, animal wastes, biomedical wastes, construction wastes, industrial solid wastes, sewer, biodegradable wastes, non-biodegradable wastes, and hazardous wastes.